LARGE-SCALE PHYSICAL MODELLING OF A BROKEN SOLITARY WAVE IMPACT ON RIGID AND NON-RIGID BOX-LIKE STRUCTURES

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INTRODUCTION

Recent tsunami disasters such as the Palu Tsunami 2018 in Indonesia demonstrated the significant hazards caused by such extreme hydrodynamic events. In the case of near-field events, tsunami-safe buildings are mandatory to prevent loss of life. Designing tsunami-safe buildings relies on engineering codes to estimate induced loads. The only such design code, written in mandatory language is "Chapter 6 - Tsunami Loads and Effects" published recently in the ASCE 7-16 (2017). Another design guideline is the MLIT (2011) elaborated in Japan. However, prescriptions of tsunami loads and the associated force distributions differ to a large extent among these codes.

In this study, for the first time, a bore originating from a solitary wave was used to investigate the damage to an idealized structure at relatively large scale (1:5). Therefore, model tests with rigid and non-rigid structures were combined to provide a unique data set of pressure distributions and structural response. This data set could be used to model structural behavior more realistically within the Froude-Cauchy similitude. An experimental study by Park et al. (2017) was conducted to measure pressure and force distributions of regular, irregular and transient waves on a rigid structure. Due to the structural rigidity, the structural responses were outside the scope of this study.

EXPERIMENTAL SETUP

An experimental study of broken solitary waves impacting a box-like structure was performed in the Large Wave Flume in Hannover, Germany (307 m × 5 m × 7 m).
A sketch of the experimental setup is shown in Figure 1, which includes the location of the instrumentation used.

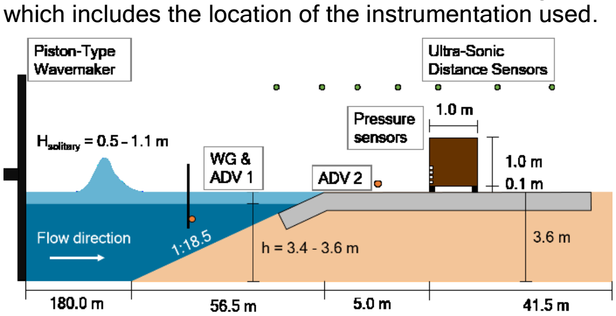

Figure 1 - Experimental setup of the rigid structure model tests including the instrumentation used (not to scale).

A box-like structure was used to model buildings observed during a post-tsunami survey conducted by the authors in 2018 in Palu, Indonesia. The model included a gap, observed in the field, between the ground and the lower level floor, preventing casual flooding and rodent protection. The box had dimensions of 1 m × 1 m × 1 m and was built on footing structures with a height of 0.1 m. The footing structure allowed to set the box on small concrete piles to test structural deterioration during hydraulic tests.

Four (4) pressure sensors were mounted on the front face of the structure to measure the time-history of the pressure distribution on the structures, while non-rigid structures were equipped with accelerometers to capture the structural response of the applied forces.

This is one of the first models to test towards collapsing structures with concrete piles of diameters from 27 and 40 mm to display the effect of shearing failure in hydraulic engineering. Aluminum footings were used as reference to isolate the influence of dynamic structural response.

PRELIMINARY RESULTS

An integration of measured pressure time-histories allowed to compare them with force calculations based on the aforementioned code/guideline. Results of these calculations are shown in Figure 2.

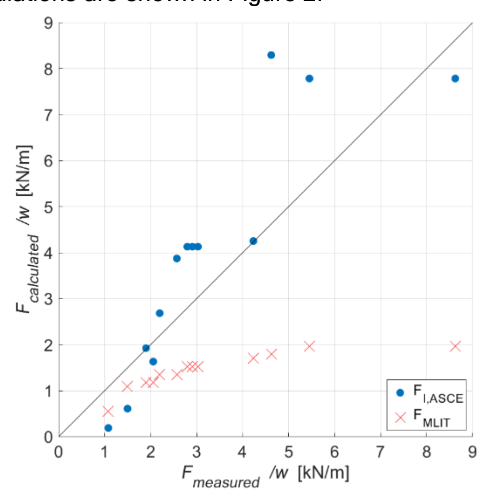

Figure 2 - Forces per unit width - a comparison of the measured and calculated forces according to ASCE 7-16 (2017) and MLIT (2011).

The impulse forces calculated according to ASCE 7-16 (2017) overestimated the measured forces while the MLIT (2011) undervalued them. It was further observed that non-rigid structures sheared as soon as the wave loads surpassed the available bearing resistance of the concrete pillars.

REFERENCES

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