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WAVE LOADING ON WAVE RETURN WALLS WITH SHALLOW FORESHORES: A CASE STUDY FROM THE FLEMISH COAST

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1. Introduction

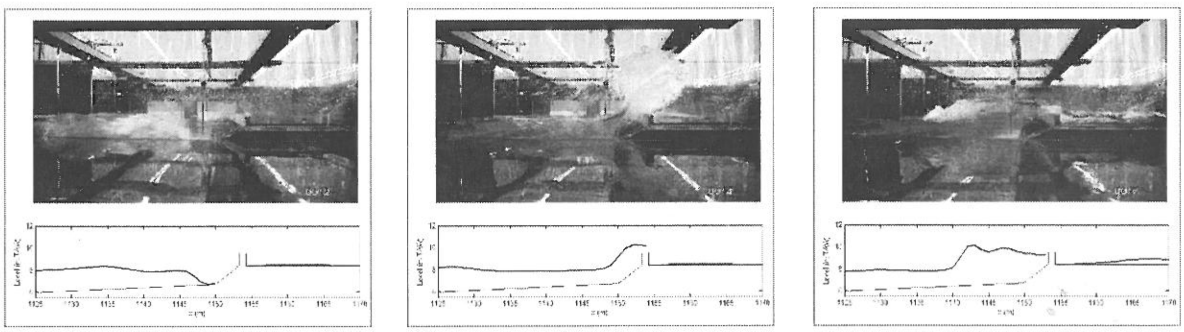
A masterplan to strengthen weak links in the Belgian coastal defence line was established and approved by the Flemish government in 2011 (Afdeling Kust & Waterbouwkundig Laboratorium, 2011). One of the measures outlined in this plan is reduce the risk of wave overtopping at the Belgian coastal town of Wenduine, by construction of a new wave return wall on top of the existing sea dike. The geometry of the new wave return wall was optimised by performing wave overtopping tests using both a 1:25 scale physical model and numerical model. Results from wave overtopping tests are described in (Veale, et al., 2012).

Wave load measurements are also required for detailed design of the proposed wave return wall. This abstract outlines the experimental setup and preliminary measurements from physical model tests to determine wave loading on the proposed wave return wall during extreme storm events.

2. Background

The foreshore at Wenduine is very shallow and therefore wave breaking plays an important role for wave loading of the proposed wave return wall. Physical and numerical model tests have shown that the swash zone offshore of the existing sea dike at Wenduine is characterized by the generation of low-frequency waves due to wave breaking, and the formation of solitary bores which collapse at the shoreline and then propagate up the beach face, as indicated in Figure 1. This finding has also been observed in previous studies on wave propagation on shallow foreshores (see e.g. Zijlema, et al., 2011; van Gent, 2001)

Traditional empirical methods to predict wave forces on breakwaters and vertical walls (see e.g. Goda, 2000; Kortenhaus, 1999; Takahashi et al., 1994) have been developed from physical model experiments largely focused on deep water wave conditions. These empirical methods do not necessarily apply for the shallow foreshore at Wenduine, and therefore investigation into wave loading on the proposed wave return wall at Wenduine are being carried out at Flanders Hydraulics Research laboratory.



t = 0.00 s (model)   t = 0.36 s (model)   t = 0.52 s (model)

Figure 1. Physical and numerical model depiction of largest overtopping wave during simulation of 1000 year storm.

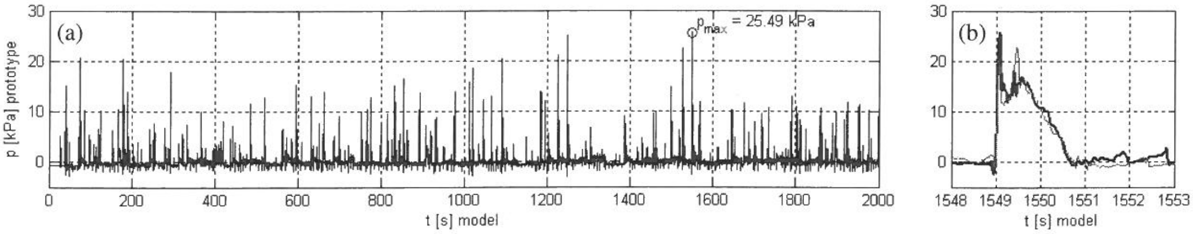


Figure 2. (a) Wave impact pressure measured with load cell on vertical wave wall during test of 1000 waves; (b) wave impact pressure measure with load cell (thick line) and integrated from pressure sensors (thin line) for largest overtopping wave

3. Experimental Methods

A 1:25 scale, two-dimensional cross-section of the existing sea-dike and foreshore at Wenduine was constructed in the large wave flume at Flanders Hydraulics Research laboratory, with dimensions 70 m long, 1.4 m high and 4 m wide. Wave overtopping tests have indicated that a stilling wave basin arrangement, consisting of two approximately 1.1 m high walls (with parapets) separated by 10 m, meet the tolerable mean wave overtopping discharge criteria of $q < 1$ l/s/m and $q < 100$ l/s/m for the respective 1000 Year Storm and +8.0 m TAW Superstorms, as required by the Flemish Coastal Safety Masterplan (Afdeling Kust & Waterbouwkundig Laboratorium, 2011).

Measurements of wave loading (force and pressure) on the seaward wall, the second stilling wave basin wall and on buildings situated on the sea dike are required. To measure horizontal and vertical wave loading, an array of pressure sensors and load cells will be installed in the walls and building elements. The pressure sensors and load cells will be logged at 1000 Hz in order to capture both "pulsating" wave loads as well as any potential "impact" wave loads resulting from the solitary bores.

Force and pressure measurements will be made for the entire model run (i.e. 1000 waves) in order to measure the maximum horizontal and vertical forces from a tests of 1000 waves, and to allow probabilistic descriptions of the measured data to be derived. An example of wave impact pressure measured by the wave load system, during a test of 1000 waves, is illustrated in Figure 2.

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