Analysis of overtopped wave loads on storm walls at the Belgian coast - A process based approach by means of hydraulic modelling

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Introduction and objectives

In several cases along the coasts of low-lying countries storm surges cause wave overtopping over the primary sea defences. Additionally, wave induced impacts at the secondary coastal defense structure or building may occur. Typically the set-up for the Belgium coastline is comprised of a dike (primary sea defence) and a storm wall (secondary sea defence) or buildings in cross-shore direction. The flow formation after overtopping, spatial variation over the crest and final interaction of the overtopping flow with the storm wall are not sufficiently investigated and design guidance is limited. Site specific cases can be found in literature (Kortenhaus et al., 2008) and various underlying physical processes are not completely understood (Allsop et al., 2004). Hence, the design of storm walls is solely based on the reduction in overtopping not taking into account the hydrodynamic loading due to overtopped waves (Verwaest et al., 2011). The main objective of this study is to gain more insight in the different processes leading to wave induced loads on storm walls, located on top of sloping structures. These processes are identified, key parameters systematically varied and linked to the loads on the storm wall.

Experimental set-up

Physical experiments were conducted in the 30 m long, 1.2 m high and 1 wide wave flume at Ghent University in March 2015 (model scale 1:25). Several configurations were tested for a long foreshore (slope of 1:35) together with a dike (slope of 1:2) and promenade widths of 10 m and 30 m in prototype. The crest elevation and water level were varied, resulting in freeboards between 1 m - 3 m. A standard offshore wave spectrum with 1000 waves was used for each test with different spectral wave heights $H_{m-1,0}$ in between 2 m and 4.75 m offshore. According peak wave periods ranged between Tp = 8.5 s and 13.15 s. The resulting spectral wave heights at the dike toe ranged between 0.526 m and 2 m. Due to wave breaking on the shallow foreshore long waves were found at the dike toe location. Measurements were taken from wave conditions at the dike toe, the mean and individual overtopping, layer thickness and velocity on the crest and the wave-induced pressures and forces on the storm wall.

Results and discussion

Good agreement for both, load and overtopping measurement, with the findings from literature was shown. The overtopped flow layer thickness and speed have been studied in more detail and were related to the measured forces on the storm wall. The overtopped flow can be described as a bore wave travelling over the promenade until impacting the storm wall. An average speed was determined by the signal of two wave gauges placed after each other in flow direction on the promenade. The layer thickness was retrieved from the same wave gauge signals. It was found that the data set can be split into dynamic and quasi-static loading cases, as described in extended PROVERBS parameter map for vertical breakwaters (Kortenhaus and Oumeraci, 1998). The research of bore characteristics (layer thickness and speed) and their relation to the loads on the storm wall will support an improved design guidance for storm walls and buildings on top of dike structures.

References

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