HYDRODYNAMIC MODELLING OF WAVE OVERTOPPING OVER A BLOCK-COVERED DIKE

Wave overtopping is one of the main failure mechanisms of a dike. The water that overtops the dike reaches the landward slope of the dike, where it can cause erosion due to high flow velocities and turbulence that causes high stresses on the cover. Therefore, innovative block revetments such as Grassblocks have been developed by Hillblock to protect the subsoil of the dike against erosion and are installed between the grass and subsoil of the dike. The blocks have a permeable function which reduces the flow velocity and pressures along the landward slope. The performance of these blocks is assessed in physical tests, which provides insights into the stability of the blocks, but these tests are also expensive and have limitations in their measurements due to highly turbulent conditions. Numerical models can provide the flow conditions on any location and the dike geometry and wave conditions can be easily adjusted. Therefore, the goal of this study has been to determine the hydrodynamic conditions on the dike cover caused by the wave run-up on the seaward slope and by the overtopping flow over the crest and landward slope.

The geometry and wave conditions from the physical test at the Delta flume of Deltares have been implemented in OpenFOAM, a CFD software package. Using the solver porousWaveFoam, which is included in the waves2Foam toolbox, a porous layer on the crest and landward slope has been implemented which represents the permeable function of the Grassblocks. The flow resistance F_p of this porous layer largely depends on the resistance coefficients α [-] and β [-]. The model has been calibrated using different combinations of the resistance coefficients based on research by Van Gent (1995) [α = 1000, β = 1.1], Jensen et al. (2014) [α = 500, β = 2.0] and Losada et al. (2008) [α = 200, β = 0.8]. Comparing the modelled and observed peak pressures and peak flow velocities of each overtopping wave (Fig. 1) showed that the resistance coefficients as introduced by Jensen et al. (2014) performed best for the peak flow velocities (NSE = 0.315) and pressures (NSE = 0.266). The validation also proved that the model works relatively well for the peak flow velocities (NSE = 0.606) and pressures (NSE = 0.154).

The validated model then has been used to determine the hydrodynamic conditions on the landward slope. Video analysis of the physical test showed that the Grassblocks collapsed at the toe of the landward slope after 300 s. The hydrodynamic conditions showed that especially the pressure at this specific location was highest at this moment, which was caused by a large flow thickness and high flow velocity. Eventually the model has been used to determine which block specifications can reduce the hydrodynamic conditions the most. A sensitivity analysis showed that a porosity of n = 0.6 and the porous layer thickness of 36mm resulted in the largest pressure reduction.

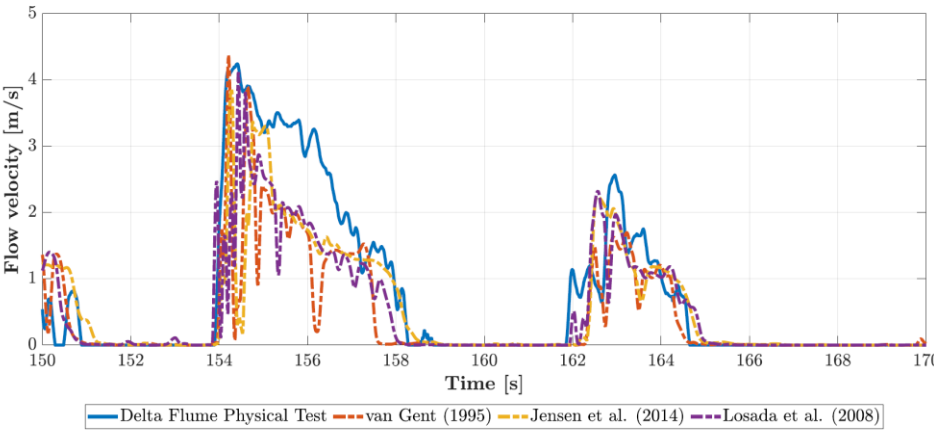

Figure 1: Observed and modelled flow velocity using resistance coefficients of Van Gent (1995), Jensen et al. (2014) and Losada et al. (2008).

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