OVERFLOW AND WAVE OVERTOPPING OVER BROAD QUAY WALLS MODELED WITH OPENFOAM

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INTRODUCTION

In the framework of the EU Floods Directive, Flanders Hydraulics Research (FHR) is performing flood modeling studies to evaluate the flood risk along the Belgian coast due to extreme storm surges on the North Sea. Thereto, amongst others, the failure behavior of quay walls in the coastal ports must be determined. Computing the landward non-impulsive wave overtopping discharge over a broad quay, in some cases combined with overflow, on which a flood wall can be present at large distance [O (100 m)] from the front edge poses a particular challenge. This matter, to the authors' knowledge, is not covered in existing literature, e.g. the European Overtopping Manual. It is also not possible to apply the method for reduction of wave overtopping over a wide crest according to Verwaest et al. (2010), since it was developed for breaking waves on a shallow foreshore overtopping a sloping dike, requiring the determination of a run-up level. It is clear that the landward water flow on the quay should be investigated in more detail, as it is characterized by bottom friction and possible inertia due interaction with the flow reflected at the flood wall. To this end, the CFD toolbox OpenFOAM is used to model the final discharges at the landward side of the quay.

PROBLEM DEFINITION

A definition sketch of the problem is given in Fig. 1. Incident waves with significant height H_{m0} and mean spectral period $T_{m-1,0}$ propagate in direction of the quay with water depth h in front of the wall. Freeboards $R_{c,1}$ and $R_{c,2}$ are defined at the front wall edge and at the flood wall, respectively (the latter is optional). The quay is defined by a slope 1:cot α and horizontal length L_q. No roughness of the quay surface is taken into account. The (optional) flood wall height is defined by h_w. The average discharge over the front quay wall is denoted by q_1, the discharge at the landward side (behind the flood wall) q_2.

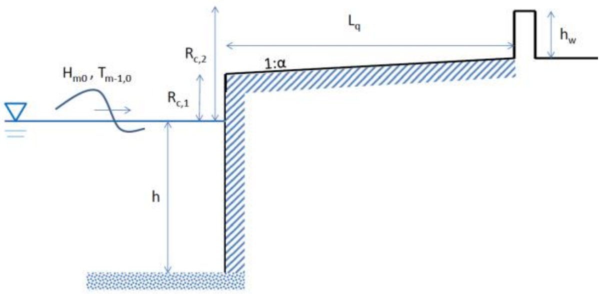

Figure 1 – Problem definition sketch

NUMERICAL TEST SETUP

Wave generation and absorption boundaries implemented in the olaFlow solver are used, integrated in OpenFOAM version 5.0 released by the OpenFOAM Foundation. Since long irregular wave trains are generated in combination with a highly reflective quay wall, accurate and efficient active absorption at the wave boundary is a must. The numerical experiments are limited in a first stage to a 2D domain (perpendicular wave attack), to be extended in a later stage to a full 3D model considering oblique wave incidence. A mesh with variable cell size is used to optimize the computational cost, respecting a maximum cell size of H_{m0}/10 around the still water line.

olaFLOW is based on the interfoam solver for two-phase flow, which uses an algebraic free-surface modeling method based on the interpolation of the fluid fractions. Tests are performed in a laminar regime and with a k-ω SST turbulence model. Solver settings for the solution of the coupled pressure-velocity equation and the advection of fluid fraction are adopted from Higuera (2015).

VALIDATION OF THE MODEL

In a first step the modeled discharge q_1 over the front quay wall is validated with the EurOtop formula for plain vertical walls under non-impulsive overtopping without influencing foreshore. In a second step, the reduction due to the storm wall will be validated using physical scale model tests carried out in the wave tank at FHR (Dan et al., 2015).

RESULTS AND CONCLUSIONS

Preliminary tests have been carried out with a quay wall setup h =12 m, R_{c1} =0 m, α = 0, T_{m-10} = 3s, H_{m0} =1m, L_q = 100 m. A snapshot of wave overtopping over the front quay wall is given in Fig. 2. Full results of validation and conclusions on the ongoing research in terms of mean and individual overtopping discharges will be provided in the conference presentation and proceedings.

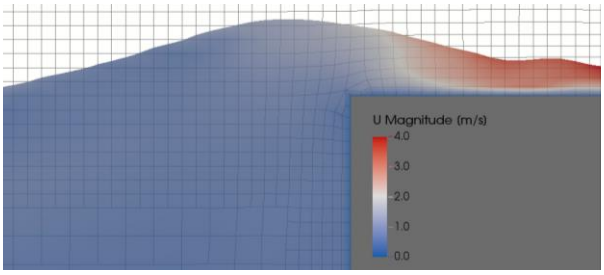

Figure 2 – Wave overtopping over front quay wall

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