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PHYSICAL MODELLING OF WAVES INSIDE THE NEW HARBOUR OF OSTEND

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1. Introduction

Ostend is one of Belgium's most popular seaside resorts and its port provides an easy access to the city. The harbour is located very close to the city center. The old town is located at the west side of the harbour with a relatively low ground level (approx. equal to the mean height of the sea level). A severe damage can take place at the nearby city area and nearby buildings by flooding of storm waves which can penetrate the harbour. The Flemish government has decided to protect the city from severe storms and to enlarge the harbour by a new design of the harbour access. It was decided to replace the old (curved) access defined by two wooden piers and low-crested dams underneath, by a new access channel perpendicular to the coastline together with the construction of two breakwaters (Verhaeghe et al., 2010).

These modifications will affect the wave conditions inside the harbour. The present study is focused mainly on predicting and simulating the future wave conditions inside the harbour of Ostend after the new planning of the harbour entrance. This wave study provides the hydrodynamic boundary conditions to design any defense structures inside the harbour. Moreover, the new results can be used to for numerical wave models validation (e.g. MILDwave model, Troch, 1998).

2. Experimental studies

A physical scale model (scale 1:100) of the harbour configuration was constructed in the wave basin of Flanders Hydraulics Research (Hassan et al., 2011) to achieve the research goals. The physical model was built in an area 20.0 m long, 14.0 m wide and 0.49 m deep. A piston type wave paddle generates the random waves inside the wave basin. Waves were measured at more than 60 locations in- and out-side the harbour. Several storm wave conditions in combination with various water levels (SWL between +6.0 and +8.0 m), significant wave heights (4.0 to 5.5 m) and peak wave periods (+6.0 to +12.0 s) were used during the experiments. Three storm wave directions were simulated in the wave basin by changing the wave paddle position: NW, NNW and -37° which are the directions with which the most wave energy penetrates the harbour. In total more than 40 wave conditions and more than 300 physical model runs were simulated during the tests.

This study presents results and measurements in the physical model of the new harbour (after the construction of new breakwaters). These new results are focused on studying wave penetration inside the new outer part of the harbour, inside Montgomerydock (hereafter abbreviated as MD) and include also wave transmission over/around the new breakwaters.

Wave heights at different locations inside the harbour and inside MD were measured in detail and used to compute wave penetration coefficients K_d (= H_{m0} at any location/H_{m0} outside the harbour) to investigate the efficiency of different design scenarios to reduce the gap width at the entrance of MD for reducing wave heights inside it. The wave penetration coefficients presented in this study include a comparison between four different layouts/designs at the entrance of MD. Several of the tested variants of the geometry of Montgomerydock are based on numerical results of wave heights for different configurations at the entrance of MD obtained using the numerical model MILDwave (Stratigaki and Troch, 2010; Stratigaki et al., 2010). Wave height studies include also investigation of three different designs of return wall heights around MD.

3. Results and discussion

This study provides an overview of how the significant wave heights propagate during various severe storm wave conditions into the harbour of Ostend. The measured wave heights at different locations have been used to compute wave penetration coefficients K_d inside the harbour. Figure 1 (A) presents one example of the physical model results. A comparison between the K_d values, at different locations (G03, G13, G04 and G15) along the outer part of the harbour is presented as a function of water level. These results give an indication about the wave penetration/propagation into the harbour (G03 located at the harbour entrance and G15 located more inside the harbour).

It is clear that the K_d coefficients have more or less the same values for water levels < + 7.00 m TAW (Tweede Algemene Waterpassing; Belgian standard datum level) at these four locations. On the other hand, K_d values are increased with higher water levels (> + 7.0 m TAW). This increase in K_d values were found to be highest with the highest water level (+ 8.00 m TAW). Results show that resonance/(re)reflection of waves inside MD is the most dominating process over other wave processes. Therefore, the differences between various design scenarios at the MD entrance can be ignored.

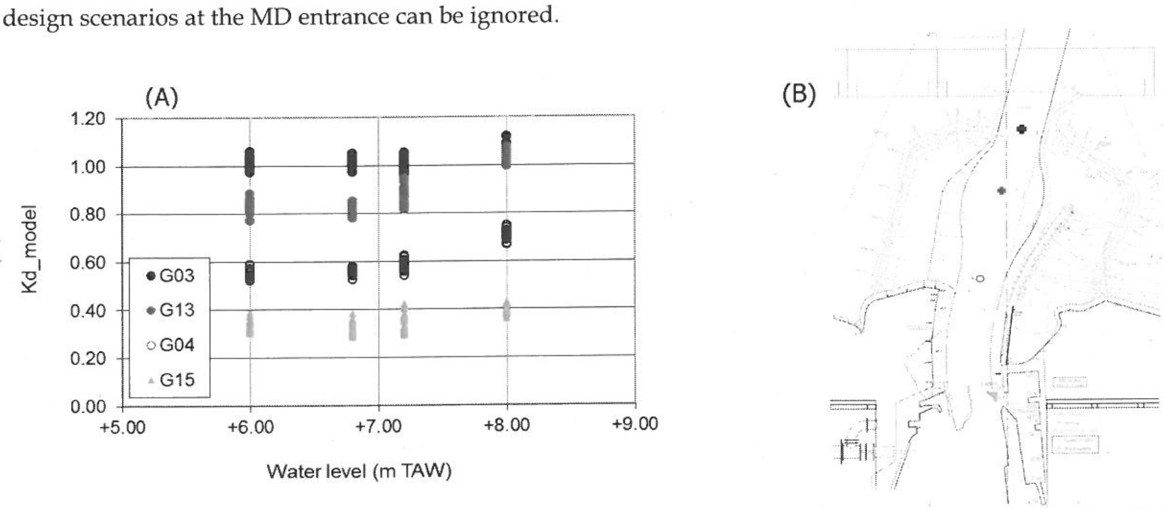

Figure 1. (A) computed wave penetration coefficient (K_d) as a function of water level, at different locations along the harbour entrance. (B) locations of the four wave gauges inside the physical model.

4. Conclusions

This paper provides an overview of how waves propagate during various storm wave conditions into the harbour of Ostend. The wave penetration was simulated using a physical scale model. The present study summaries and discusses the physical model data/results and presents all details regarding the wave conditions/processes at various locations inside and at the harbour entrance. The following points will be discussed in depth: wave conditions around the new breakwaters; comparison between the different scenarios/cases at the entrance of MD; the wave heights at different locations inside the harbour and finally the effect of return wall heights around MD on K_d values. The new results can be used for validating numerical wave models and for the design purposes of various structures inside the harbour.

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