NUMERICAL SIMULATION OF WAVE PENETRATION FOR THE NEW DESIGN OF OOSTENDE HARBOUR

Introduction

Oostende harbour is located at the Belgian North Sea coastline. An extension of the existing harbour is studied for both safety and economical reasons. A numerical simulation of the wave penetration in the new harbour entrance has been carried out using the commercial software package "Simwave".

Methodology

The planned new design of Oostende harbour includes the construction of two new breakwaters (650 m length each) which protect the existing harbour entrance and the inner harbour (Fig. 1).

Two existing piers are present along the entrance channel. The Western pier will be preserved, the Eastern pier will be removed. The trench of the navigation channel will be deepened and turned into a new angle to the coastline.

The bathymetry of the planned situation as shown in Fig. 2 is used as simulation domain in the numerical model Simwave.

Fig. 1. *Aerial picture of Oostende harbour with the new port entrance and new breakwaters on the foreground*

Waves enter the simulation domain from the offshore (i.e. left) boundary. Wave conditions at the offshore boundary have been defined from deep water wave buoy data which have been transferred to the boundary using a spectral wave propagation model. The other boundaries have been modelled as open boundaries (using the sponge layer method) allowing the waves to leave the simulation domain.

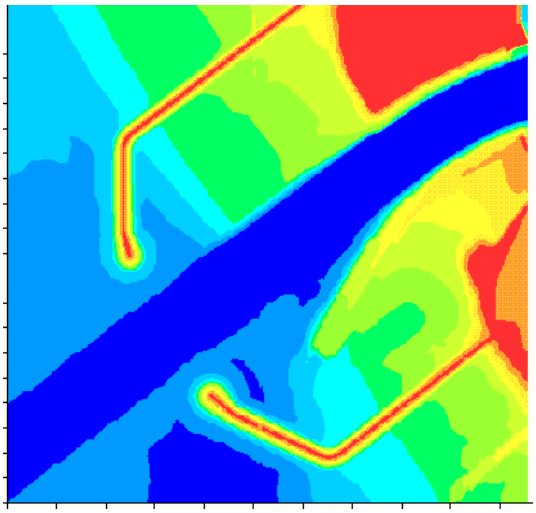

Fig. 2. *Bathymetry of the planned new design of Oostende Harbour, used for the numerical simulations.*

The software package SimWave is a set of programs for numerical simulation of wave propagation and transformation. It is based on the nonlinear time dependent Boussinesq equations. The Simwave Boussinesq model is a phase-resolving model and takes into account the non-linearity of waves, the interaction of different frequencies of irregular waves and variable water depths. Different extensions of the equations make this model applicable to a wide range of water depths. It can be used from near the deep-water limit up to the shallow water area until the shore.

Wave breaking, effects of bottom friction and wave run-up at the shore are parameterised in this Simwave Boussinesq model. Effects of refraction, shoaling, diffraction and reflection are considered by the equations themselves. The solutions of Boussinesq equations are water surface elevation η (x, y, t) and the horizontal velocities u (x, y, t) and v (x, y, t) at a reference depth.

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Results

For these numerical simulations, an area of 1.0 by 1.0 km has been modelled. The size of the individual cells has been set 2.0 x 2.0 m (i.e. 500x500 nodes).

The number of individual simulations is specified by storms characterised using different return periods. The design storm for the breakwaters has a return period of 500 years. Influence of wave period, wave height, water level and nature of wave attack (regular or irregular waves) has been taken into account.

A prototype measurement campaign is carried out to validate the numerical model results (see "Study of the wave propagation in shallow water through prototype measurements").

Fig. 3 shows a typical example of the instantaneous surface elevations in front of and inside the breakwaters. The irregular wave pattern is easily detected, and the penetration inside the harbour is clearly present. More results will become available soon.

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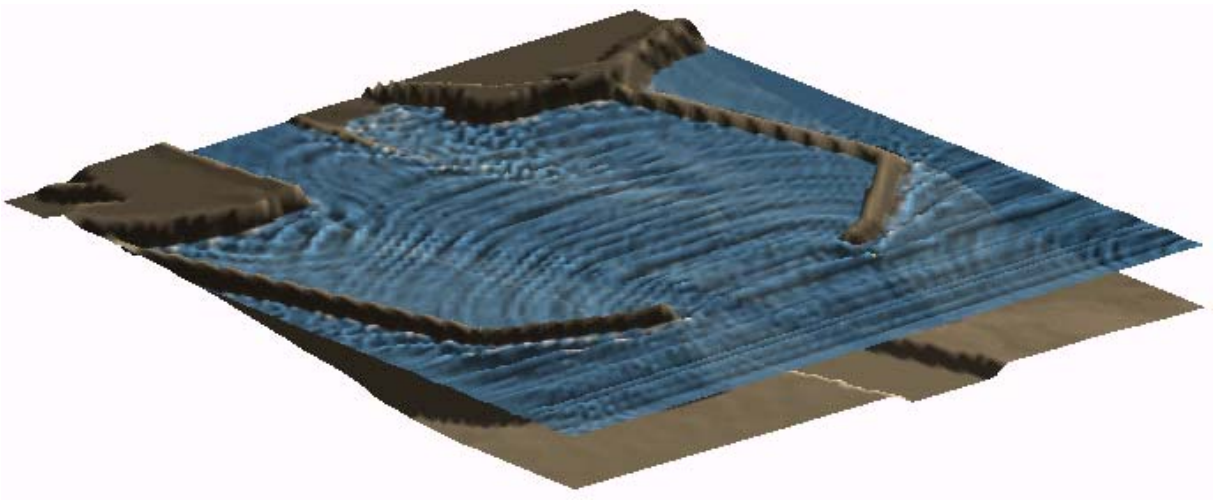

Fig. 3. *Typical simulation result showing the instantaneous surface elevations of the irregular waves propagating and penetrating the harbour area.*