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Flow in and on the Zeebrugge breakwater
- a comparison of prototype measurements, large-scale model tests, and numerical computations.

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Abstract

As part of the Mast programme (MAS02-CT92-0023) the outer breakwater in Zeebrugge, Belgium has been subjected to extensive investigations. A section of the breakwater is instrumented enabling prototype measurements consisting of wave recordings and pore pressures inside the breakwater, etc. Along with prototype measurements, large-scale model tests (1:20) have been carried out at Flanders Hydraulics, Borgerhout covering a wide range of wave conditions and corresponding tests in scale 1:40 and 1:70 are conducted in the University College Cork and Aalborg University respectively. Furthermore, as a part of the MAST programme there has been developed a numerical model at Aalborg University able to compute the flow in front of, on, and inside a breakwater structure. The main objective of this contribution is to render a comparison of results obtained by prototype measurements, large-scale model tests, small-scale model tests, and numerical modelling respectively.

The Zeebrugge breakwater constitutes a conventional rubble mound breakwater with a low superstructure and an armour layer consisting of antifer blocks.

Aiming at a more thorough description of the flow on and inside breakwater structures is well-founded as it leads to possible determination of responses such as forces on and stability off the structural elements of the breakwater, runup, and overtopping. Both prototype measurements, physical model tests, and numerical modelling are connected with different problems due to the complex physics involved and a comparison is therefore deemed to give an impression of the reliability of results, as well as founding a basis for evaluating scale effects.

The differnt approaches for determining the hydraulic response of the Zeebrugge bre-

akwater enables comparison of several entities. Related to the flow in front of and on the breakwater wave transformation, run-up and run-down levels and flow velocities are compared. Inside the structure excess pore pressures, phreatic surface elevations, damping and transmission are dealt with.

During a storm event excess pressure heights have been recorded in three positions within the prototype, placed inwards in the breakwater. Wave conditions consisted of a tide of 4.1m and waves with H_s=2.38m. During a 100s recording of waves and pore pressures each pressure wave has been pared with the belonging wave. Relating the pressures in the measuring points with the wave height yields damping ratios which comprises the results of the numerical calculations.

Damping is, though, more pronounced in the numerical model, where the hydraulic friction is based on the Forchheimer equation. The difference may be explained by lack of adequate knowledge about the hydraulic properties and porosities of the materials used in the breakwater.

In conclusion, it is found that physical phenomenae in front of and on the breakwater shows exceedingly good agreement between prototype, physical model tests, and numerical modelling. As for the determination of hydraulic responses within the breakwater agreement is still good, but is influenced by the complex physics involved and less reliable measuring techniques. Ongoing research is made on improving the understanding and quantification of the hydraulic
processes inside the breakwater.