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DESIGN OF STORM RETURN WALLS FOR THE MASTERPLAN FOR COASTAL SAFETY: FROM CONCEPTUAL TO DETAILED DESIGN

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1. Introduction

Although the Flemish coastline is merely 67 kilometre long, every meter is optimally used. Many stakeholders have specific interests in this varied area: housing, tourism, harbour activities, nature reserves, ... To balance the needs of all these interest groups, mutual cooperation is needed to guarantee their future. The integrated master plan for coastal safety started in 2007 and brings all these factors together. This plan was approved in June 2011 by the Flemish Government and forms the basis for the development of the seafront along the Flemish coast in the nearby and distant future (looking at 2050) with safety against flooding as a primary aim. A combination of soft and hard coastal protection techniques will be used. To detail the design of these hard measures architectural, numerical and physical modeling is being executed This abstract outlines the process of the conceptual and the detailed design.

2. Conceptual design

Both for the harbours and the coastal towns a social cost benefit analysis is made. In this analysis different measures are compared. For the coastal towns the measures consist of a beach nourishment in combination with possible hard measures at the location of the current sea wall. Possible hard measures are storm return walls and stilling wave basins. The larger the hard measure, the less sand has to be nourished (or the higher the protection level).For the harbours measures consist of storm return walls all around the harbour and a possibility to close the harbour with a storm surge barrier.

For all measures the cost is estimated based on experience of comparable projects and/or on a rough preliminary design of the structures. With flood risk calculations the (remaining) potential damage is evaluated. The higher the measure the less damage.

All the costs and benefits are compared, taking into account the social consequences. By doing so, a ranking of the different types of measures is obtained and the optimal height and dimension of the measures is determined. For this exercise no detailed calculations of wave forces and stability of the foundation were necessary. The cost benefit analysis only gives a ranking. If two measures are of comparable impact and cost, other considerations have to be taken into account for the decision, such as the social impacts. Therefore the outcome of the cost benefit analysis has to be robust for changes in costs or avoided damage, including the high uncertainty on extreme water levels, wave heights, ...

3. Detailed design

Once the measures are selected, a detailed design is necessary. For two coastal towns storm return walls in combination with a beach nourishment were selected as the best alternative. For the other coastal towns a beach nourishment was sufficient as protection measure. For the harbour of Nieuwpoort a storm surge barrier was selected as best alternative, while for the other harbours, storm return walls were chosen. The proposed dike and quay wall configurations are shown in Figure 1.

During the preliminary design the following problems were identified:

- almost no literature or experimental results exist for the calculation of overtopping and wave forces over/on a storm return wall on top of a dike or quay, with a horizontal berm between the quay/dike and the wall;

- waves in a harbour travel under a very oblique angle with the quay walls which results in a large decrease in wave impact, but almost no material is available for quantification of the effect;
- using physical models might result in important scaling effects.

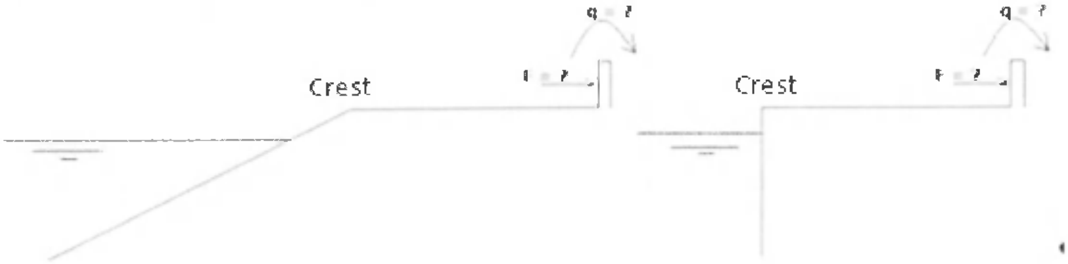

Figure 1 Schematised dike and quay wall

For this reason extended research was proposed:

- organising prototype measurements (with the Wave Overtopping Simulator)
- organising near prototype measurements
- extended program in smaller wave flumes
- extended program in a wave tank

The prototype measurements have the advantage that the water layer and storm walls are on real scale. The drawback is that only a limited number of conditions can be modelled and that the generation of the water layer over the dike is not exactly the same as in reality (simulated by the Simulator). The near prototype measurements have the advantage that the water layer is generated by real waves, but scale effects are already possible. The results of these tests can be used to compare with the results for comparable experiments in a small wave flume, to identify scale effects.

4. Wave overtopping simulator

The Wave Overtopping Simulator, normally used to test the stability of the leeside of an overtopped grass dike, is now used to test wave impacts on a storm wall at full scale 1/1. This 22 m^3 water tank of 4m wide is installed at a 10 m horizontal "road". At the end of this road two aluminium plates were placed which represent a storm wall at 10m distance from the overtopped quay wall or dike. The aluminium plates are equipped with 4 force sensors, 1 in each corner of the plate. Furthermore, the layer thickness and velocity of the incoming wave is measured.

5. Near Prototype measurements

A test campaign was carried out in June 2011 in the Grosser Wellenkanal of ForschungszentrumKuste in Hannover with a real dike and real waves. A dike with slope 1/3 was built in the flume with a crest at 6.5m above the flume bottom. A 10 m long platform of concrete tiles and a storm wall were built at this crest. The water level was at about 5 m above the flume bottom, and waves of 1m to 1.5 m high and wave periods from 8 to 12 seconds were created. Tests could be considered to be on scale 1:2 to 1:3.

6.Extended program

An extended campaign is going on with tests in smaller wave flumes and a wave tank, in order to test the various hydrodynamic conditions and layouts along the Belgian Coast. In the wave tank, the influence of oblique wave attack will be tested.

7. Conclusion

A preliminary design is made based on the limited available knowledge of overtopping and wave forces on complex dike and quay layouts. After a final choice is made, an extended test program is set up.