

Comcoast

Approach to the innovative design of an overtopping discharge resistant dike

Final

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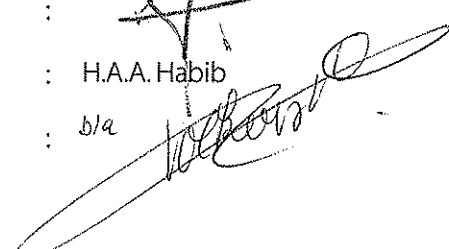
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1 Introduction

Comcoast is a European project being carried out within the framework of the Interreg IIIb-North sea programme.

Word Package 3 (WP3) is one of the 6 work packages of Comcoast. WP3 deals with the technical development of the Comcoast concept.

The objective of Comcoast (Combined functions in coastal defence zones) is to investigate how a multifunctional wide sea defence zone might be created. Instead of just increasing the height and weight of the dike, solutions are searched in the wide sea defence zone landward. There is a number of technical solutions, one of them is increasing the dike strength in order to resist the load of water flow upon the grass revetment during extreme storms and handling the incoming water.

WP3 aims at developing new concepts or further study of existing concepts together with the market parties to increase the dike strength in order to resist wave overtopping. The new concepts need to be cost-effective and social and environmental acceptable.

2 The Concept

2.1 General

The concept proposed by Grontmij-Witteveen+Bos is based on the stilling/retention basin idea that could be applied at the upper side of the inner slope. The stilling/retention basin has to be embedded in the body of the dike. The idea of the stilling/retention basin can be described as follows.

The concept arises from a logical sequence of steps. The innovative character of this concept is that it does not focus on the improvement of the erosion resistance of the inner slope, keeping in this way the inner slope undisturbed. Instead the problem is tackled from its source, as such keeping the inner slope undisturbed. In the stilling/retention basin the overtopping discharge is caught and regulated. Some of the overtopping water volume can be discharged through a closed drainage system. Furthermore, in this concept the peak discharges are attenuated.

The starting departure point for the design of the stilling/retention basin concept is maintaining the grass revetment in the inner slope. As such the landscape value of the grass revetment could be preserved, which we consider to be an added value with respect to the environmental developments that have been planned in the area behind the Hondsbossche Sea defence.

The stilling/retention basin is a simple and flexible concept implying relative small intervention and promoting landscape and recreational values.

2.2 Description of the concept

2.2.1 Foundation of the idea

The innovative concept combines the functions of capturing and regulating the overtopping discharge within the cross section of the dike. The concept consists of two parts:

1. The stilling/retention basin;
2. The drainage system.

Ad 1. The stilling/retention basin has three functions, namely:

- energy dissipation: the water velocity on the inner slope is reduced;
- collector and distributor of the overtopping discharge into a free surface water flow over the slope and a water flow through the drainage system. The amount of water that is allowed to flow over the grass revetment is therefore controlled in such a way that the risk of erosion and softening of the inner slope is minimised;
- the attenuation of the peak loads (the large overtopping volumes for the strongest waves from the wave fields).

The main characteristics of the basin are:

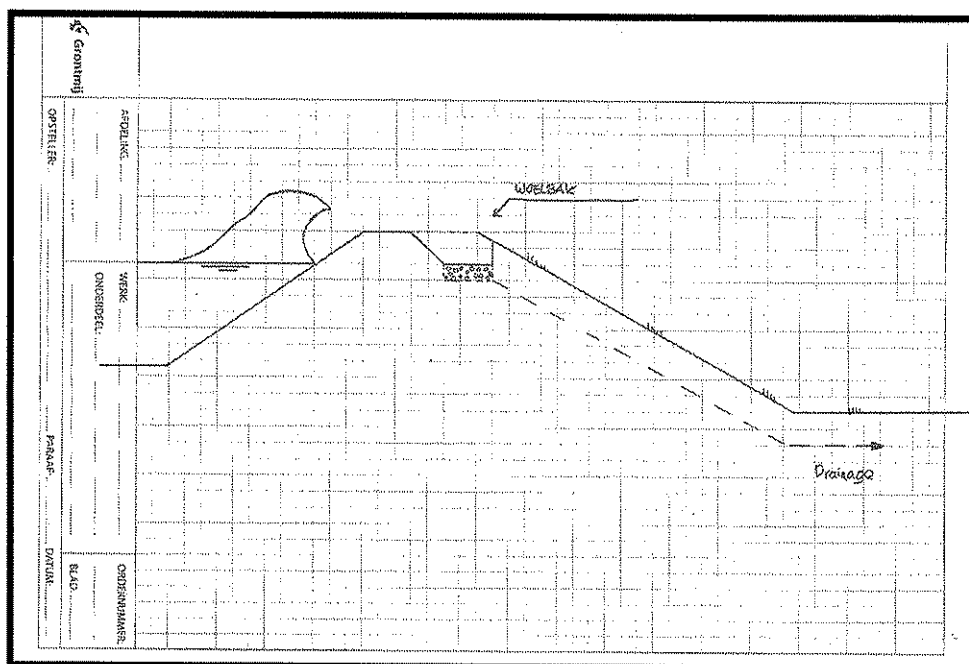
- the stilling/retention basin is embedded in the body of the dyke and does not emerge above the crest. The landscape is therefore not affected;
- there are several alternatives for the drainage system;
- the grass revetment can be preserved (except from temporary removal during construction for implementation of the drainage system).

The following materials might be applied in the construction of the stilling/retention basin and crest protection:

- prefab concrete;
- polyester;
- open asphalt system on geotextile;
- colloidal concrete on geotextile;
- prefabricated Erosion Prevention element;
- recycled materials.

The alternatives of the drainage system are:

- synthetic pipe;
- concrete gutter;
- drainage mat.



2.2.2 Degree of innovation

The SOTA alternatives are directed at -and as such limited to- the strengthening of the inner slope protection. Our solution is focused upon the reduction of both loads and velocities at the inner slope. It is still feasible that our stilling basin concept is combined with one of the concepts from the SOTA-study. As such the stilling basin is complementary; its design can be adapted as such that an optimum total solution is obtained.

2.2.3 Permissible wave overtopping discharge

The principle of the stilling/retention basin is based on the fact that a part of the water volume is allowed to flow down to the inner slope and that the rest is blocked and discharged through a drainage system.

The maximum discharge that is allowed to flow over the inner slope is related to the resistance capacity of the grass revetment against erosion. The maximum permissible overtopping discharge through the system (inner slope and drainage) is 15 l/s/m.

2.2.4 Relevant dike failure mechanisms

The stilling/retention basin is an element in the body of the dyke.

Failure mechanisms are) the exceedance of the maximal horizontal load upon the basin structure and) the erosion at the interfaces between the basin structure and the dike. Furthermore the drainage system can always be blocked. Finally, the chance on surface erosion of the inner slope/crest and rupture (sliding or saturation of the inner slope and top layer) as examined in the SOTA study, in theory also hold for our concept.

2.2.5 Construction phase and risks

Part of the crest and inner slope is temporary removed in order to construct the stilling/retention basin. The inner slope is removed in order to implement the drainage system. The main risk during construction is when the dike is confronted with extreme wave attack during a storm. Therefore the construction works should be carried out off storm season.

2.2.6 Lifetime indication

The materials to be used in the design should be chosen for a minimum lifetime of 50 year. More-over the concept should be designed for the extreme wave conditions and loads corresponding to the total lifetime of the structure.

2.2.7 Cost indication

In order to make a competitive design the costs of the traditional approach, namely raising the dike should be known. The costs of raising a dike by approximately 3 m are taken as a reference. The total price per cubic meter soil/sand (purchasing and processing) is estimated to be Eur 8,-.

Hondsbossche Zeewering

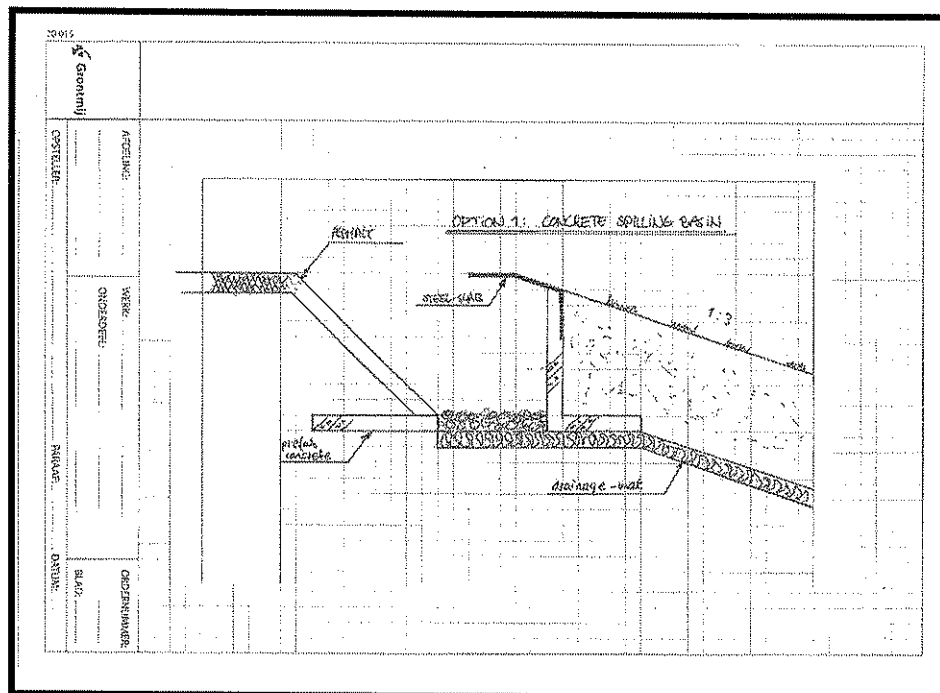
The costs for the raising of the dike of the Hondsbossche Zeewering will be about EUR 960,- per meter length of dyke.

We expect that it is feasible to construct a prefab concrete basin and a drainage system -consisting of a drainage mat- for approximately the same price. The prefab concrete then must be produced in series.

According to first ideas about materials and dimensions the cost for the spilling basin will amount to € 940,- per meter dike. This can be specified as follows:

- prefabricated concrete section, € 235,-
- steel slab, € 235,-
- drainage-mat, € 320,-
- placement, € 150,-

Prices are without VAT and based on unitprices from 1st January 2005.



2.2.8 Maintenance and operational aspects

We expect that the operation and maintenance costs can be kept of the same order as regular maintenance of the dike. The stilling/retention basin should be regularly checked and kept clean by removing debris and garbage. The drainage system should also be regularly maintained in the same way as for other applications. The grass revetment should be monitored and controlled in the same way as it is done for common applications.

2.2.9 Environmental aspects during the construction and application

The stilling/retention basin is embedded in the body dike with no negative influence on the landscape. The preservation of the grass revetment gives an extra value in terms of landscape values.

2.2.10 Experience with the concept

The stilling/retention basin and the drainage system are frequently applied systems. Stilling basins are for instance widely used to reduce the energy of the flow downstream of a spillway; drainage systems are often applied to irrigation systems. This very specific application, however, at the crest of a dike in order to control the water flow over the inner slope, is new (to our knowledge).

2.3 Theoretical phase approach

The concept has to be elaborated during the theoretical phase.

At first we will pay attention to the following hydraulic aspects in particular:

- The capture of the -peak- water volumes (under design wave conditions) and the control (distribution) of the discharges down to the inner slope and through the drainage system;
- The dissipation of energy on the crest of the dyke and in the stilling basin;
- The hydraulic load upon structures;
- The relation between discharge, energy and velocity on the inner slope;
- The relation between water volume over the inner slope, duration and saturation of the grass revetment.

These hydraulic aspects will be examined by a review of literature about stilling basins and drainage systems. Relevant literature studies will be used to evaluate the hydraulic aspects of the concept. The need and discharge capacity of the drainage system will emerge from this hydraulic analysis. Also the most appropriate drainage system will be determined.

For both the Hondsbossche Zeewering and Westkapelle a conceptual design will be elaborated. The concept will be described in more details and, where possible, in quantitative terms. The overall dimensions of the basin and drainage system will be provided and the costs will be estimated. Important constructive details and materials will be specified. Drawings will be provided. The design will comply with the guidelines of TAW, 'Leidraad Zee- en Meerdijken en Leidraad Kunstwerken'.

Where applicable, the strength and stability of the design will be evaluated in the framework of the VTV ('Voorschrift toetsen Veiligheid').

Finally a proposal will be made for the test phase. This proposal consists of a research program including:

- definition of the issues;
- description of the laboratory tests;
- definition of the hydraulic boundary conditions to be examined;
- estimation of the costs.

Next to the technical aspects of the concept, also a quick assessment study will be conducted into the procedures, legal issues and permits that are related to the implementation of the measures. Also an overview will be provided of all relevant stakeholders and the authorities that will be involved in the issues of permits.

2.4 Global plan test phase

Physical model tests of the concept will be carried out to prove that the design can successfully cope with the required wave overtopping discharge.

The model tests will be focused upon the main mechanisms of the basin concept:

- the attenuation of peak discharges;
- the distribution into a free surface flow over the grass revetment and a water discharge through the drainage system, time averaged as well as during peak loads;
- the reduction of flow velocities at the inner slope.

Furthermore, measurements should give insight in:

- the relation between discharge, energy and velocity on the inner slope;
- the relation between water volume over the inner slope, duration and saturation of the grass revetment;
- the potential failure mechanisms.

The results from the test-phase should lead to confirmation or modification of the design assumptions and theoretical conclusions. It should also lead to an improved design for the concept of the stilling basin.

3 Planning and costs

The final report will be issued on 31 July 2005, for an assignment of the theoretical phase given by 31 May 2005.

The costs for the execution of the theoretical phase are Euro 19.750,- exclusive BTW. These costs are specified as follows:

- Hydraulic analysis, € 7.950,-
- Preliminary design of basin and drainage system, € 3.650,-
- Drawings, € 2.450,-
- Cost estimate, € 450,-
- Report, € 2.800,-
- Project management (including 1 start and 1 final meeting with client), € 2.450,-