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Coastal defence solutions (approach of ComCoast)

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1. Introduction

Along the North Sea coast, water levels are rising and waves are intensifying due to climate change. The best scientific evidence suggests that both phenomena are likely to accelerate over the coming decades. In some North Sea coastal areas also land is sinking and tidal heights and rates of erosion are increasing. This means that the risk of flooding is increasing while more people are living, working and spending their leisure time within the coastal flood plain. With the pressure to build more housing, planners are considering options for development in coastal areas. Flood risk, the environment and a dynamic coastline have to be balanced with this pressure for development.

ComCoast is looking at how we use the coastal flood plain today and is seeking multifunctional solutions for its sustainable use in the future. The ComCoast concept is to create a more gradual transition from sea to land, instead of a traditional single line of water defence. The project is developing innovative flood risk management strategies to include wider social and environmental functions such as recreation, fishing, tourism and habitat creation. This approach aims at to highlight possibilities for developing the coastal area with respect to spatial planning, to benefit local and wider communities as well as maintaining the environment.

2. Aims

Raising awareness of coastal issues is very important. We need to plan now so we can move forward and maximise opportunities in the future. Changing coastal defence systems takes time, so ComCoast aims at streamlining the processes that influence spatial planning. This will allow us to reduce flood risk, enhance ecosystem quality and create wider societal benefits. All in all ComCoast aims at:

1. Identify suitable North Sea coastal locations, where multifunctional flood management schemes can be applied;
2. Evaluate the wider socio-economic benefits to increase the value of multifunctional sites;
3. Develop innovative technical solutions that promote alternative uses of flood management sites;
4. Influence current public participation techniques to improve stakeholder engagement;
5. Apply new approaches in coastal management, to be trialled at European Pilot sites;
6. Share knowledge and lessons learnt within and between the partner countries.

ComCoast adds credibility to flood risk management projects, it aims at increasing public acceptance of new schemes and strategies through good public participation. Alternative solutions may be possible which will benefit local communities and the environment. You can find a list of some ComCoast solutions later in this paper. These solutions are ideas for coastal management; how these ideas are used will depend on local circumstances, see ComCoast (2006).

3. Solutions

3.1 Introduction

ComCoast focuses on sea dikes. The height of a sea dike is the sum of the design water level + freeboard. The required freeboard mainly depends on the acceptable amount of overtopping (traditionally in the order of 1 litre per second per meter dike). One may try do design dikes with lower freeboards. This may be achieved by:

- decreasing the wave load on the dike;
- allowing more overtopping.

Lowering the dike below the design water level usually gives so much overflowing water, that this option is not realistic. This implies that ComCoast solutions are especially attractive in cases of dikes with considerable wave attack. Decreasing the wave load is possible by solutions in the foreshore; allowing more overtopping requires inshore solutions plus adaptation of the inner slope of the dike.

3.2 Foreshore solutions

Two foreshore solutions are investigated:

- Foreland protection: to build a sustainable defence in front of the primary defence to provide a brackish area between the water defences for habitat or farming practices. This area can be flooded up to 10 times per year. Two options exist, i.e. 1. protection of the foreland by constructing a soft embankment that acts as a buffer for the primary defence, 2. maintaining the foreland by constructing and maintaining land reclamation fields.
- Foreshore recharge to restore the coastline: eroded sediments are replaced by pumping dredged materials on top of the eroded foreshore. The dredged material (mud, sand and gravel) would otherwise be dumped at sea and lost. The new sediments reinforce the natural flood defence and also help to restore habitats for wildlife.

3.3 Landward solutions

Three landward solutions are investigated:

- Overtopping defence: making the water defence resistant to wave overtopping and ensuring that any water that is washed over the top can be temporarily stored and drained away. This can be done by replacing the crest of the flood defence and its inner slope with a revetment that will not wear away by severe overtopping.
- Managed realignment: allow tidal water to flow onto the coastal floodplain to reduce surge tide levels. The inter-tidal zone may silt up keeping (more or less) pace with sea-level rise and land subsidence. This can be realized by a partial or full removal of a flood bank to allow managed tidal inundation of the floodplain creating a dynamic inter-tidal zone with considerable natural and recreational value.
- Regulated tidal exchange: allow tidal inundation of the coastal floodplain in a controlled manner. This creates a transitional zone where the land can evolve over time into a more saline environment. The transitional zone may silt up keeping (more or less) pace with sea-level rise and land subsidence. This can be put into practice by regulation of tidal waters through a system of sluices and/or pumps. Low-lying land may require a secondary line of water defence.

4. Why ComCoast solutions?

ComCoast solutions are attractive because of the following reasons:

A. Managing Flood Risk
Due to climatic changes flood defences will have to cope with an increase in wave action and tidal levels. Consequently in the future the maintenance of flood defences will cost more. In some locations ComCoast concepts will provide better long-term solutions for managing flood risk.

B. Spatial development
Regions will benefit from developing a more environmentally friendly coastline which will also be more attractive for residents and visitors. For example, creating new surroundings for nature will help compensate the loss of natural coastal habitats. Land management in general is changing, for example farming practices are becoming less land based and therefore alternative incomes from recreational pursuits may prove viable at ComCoast sites.

C. Coastal erosion mitigation
Increased sea level and wave activity results in loss of beaches and inter-tidal and supra-tidal areas. Loss of internationally important habitat has to be replaced under the EU Birds and Habitats Directive. By returning sands shingles and mud to inter-tidal areas in front of sea defences we can increase the amount of habitat while affording some protection to the existing flood defences. Much of this sediment would otherwise be dumped at sea and lost to natural coastal systems.

D. Public awareness
It is important that people who live, work and visit the coast are aware of the affects of climate change. ComCoast aims to include local communities in order to create projects that meet their needs. However, expectation needs to be carefully managed and good public participation should ensure societal acceptance of the changing coastline. By identifying areas on the coast that may be suitable for ComCoast-type schemes we need to manage people's expectations and fully inform them of any changes. Visualisation tools will be key in helping stakeholders to understand how coastal areas could be developed. Through public participation we aim to inspire flood risk management with broader environmental and social appeal.

E. Sustainability
The aim of any ComCoast solution is that future generations are not faced with difficult flood risk management decisions. We should act now to work with natural processes so that large towns and developments are protected while other areas of the coast are adapted for climate change. ComCoast engineering solutions will be economical while being environmentally and technically sound.

F. Sharing knowledge
By coming together with a joint approach all five countries are sharing common problems and solutions and our partner organisations will also benefit. The pilot projects will allow us to learn from each other's work and enable application of trialled techniques in our respective countries.

5. New developments

The work is divided into several tasks (spatial sensing, socio-economic evaluation, civil engineering aspects, participatory action, pilot projects). This paper accentuates the civil engineering aspects.
In the first phase of the project an inventory was made of several existing techniques for protection of the inner slope, in order to allow large overtopping over dikes. This has resulted in a state of the art report (Van Gerven and Akkerman, 2005). This report has reviewed the following systems:

- Reinforced grass systems
- Gabions
- Concrete block mattress systems

- Rock fill protection systems
- Pitched revetments
- Geotextile sand-filled elements
- Open asphaltic systems
- Impervious asphaltic systems
- Concrete systems

The conclusion was, after a cost-benefit analysis that reinforced grass systems belong to the solutions most likely to be successful.

As a follow up, a contest was held to find new, innovative solutions. This contest has resulted in two new options for evaluation:

- In situ placement of grass reinforcement (suggested by Royal Haskoning and Infram): The existing grass cover is lifted by a special machine, the reinforcement is placed below the grass, and the grass cover is laid back. This method does not require a full removal and seeding of a new grass cover, and is therefore potentially much cheaper.
- Crest drainage dike (suggested by DHV): In the crest of a dike a longitudinal channel is constructed to collect the overtopping water, and this water is discharged in a controlled way either to the outer side, or to the inner side of the dike.

6. Grass reinforcement

6.1 Introduction

Because grass reinforcement is one of the best scoring existing systems, and because the contest had resulted in a new idea regarding the placement of such a reinforcement, it was decided to focus research on this option. One of the main aspects to be investigated is the real strength of reinforced grass under a (pulsating) overtopping. Because scale experiments are not possible, full scale tests are needed. The two main objectives of the field tests are communication and technical objectives.

6.2 Communication

The field tests should demonstrate to the public what water over and behind the dike means, creating awareness and understanding of coming flood management problems due to sea-level rise and heavier storms. Further the tests are aimed at developing means to get support among others of designers and administrators

6.3 Technical objectives

The first technical objective is to get insight into the amount of wave overtopping that an inner slope can cope with. For that purpose two types of grass revetments will be investigated: one with an existing grass revetment and one with reinforced grass. The second aim is to promote new techniques (here: smart grass reinforcement) once these techniques have been proven to be effective.

Fig. 1 Prototype of the overtopping simulator.

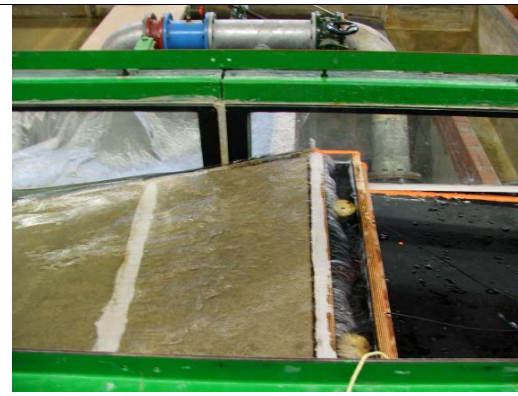

Fig. 2 Model and crest drainage trench in Delft.

This work is ongoing. An assignment has been given to Royal Haskoning and Infram to do prototype tests on a dike in the North of the Netherlands (near Delfzijl). An overtopping simulator was constructed (see Fig. 1). The prototype was tested in 2006; the complete simulator is ready and will be deployed in February-March 2007 on the dike. The simulator has a width of 4 m, and is able to give an overtopping rate in the order up to 20 l/s per meter (which implies several cubic meters per overtopping wave for the largest waves from the wave field.

7. Crest drainage dike

In the Laboratory of the Leichtweiss Institute in Hannover and in the Laboratory of Fluid Mechanics of Delft University of Technology tests are ongoing on the Crest Drainage dike. Hydraulic model tests will be performed with the following objectives:

- Variation of the shoreward slope to adopt various existing and design conditions throughout the partner countries of ComCoast;
- Optimisation of the shape and size of the basin, the side walls and the openings for seaward drainage; variations of depth and width of the basin have been included to explore the possibility of increasing the buffer capacity of the basin;
- Quantification of the shape and size of the basin, the side walls and the openings for seaward drainage; variations of depth and width of the basin have been included to explore the possibility of increasing the buffer capacity of the conditions;
- Identification of undesired outflow and other undesired conditions under the most unfavourable storm conditions;
- Measurement of the pressure field around the entire crest structure in order to identify possible weak spots for local erosion, including uplift pressures.

Hannover will focus on (i) optimisation of basin layout and water filling in the basin and (ii) different seaward slopes identification of undesired outflow. Delft will focus on (i) behaviour of construction under different foreshore conditions, (ii) influence of berms and (iii) influence of natural sea states loading around basin structure (different wave spectra). Both in Delft (see Fig. 2) as in Hannover the tests are ongoing.

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