Deltares

Process Based Modeling Of Dune Formation On The Sand Engine

Plan of Approach

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Samenvatting
This document is the plan of approach of my master thesis conserning an aeolian transport model applied on the Sand Engine.

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Status
concept
Dit document is een concept en uitsluitend bedoeld voor discussiedoeleinden. Aan de inhoud van dit rapport kunnen noch door de opdrachtgever, noch door derden rechten worden ontleend.

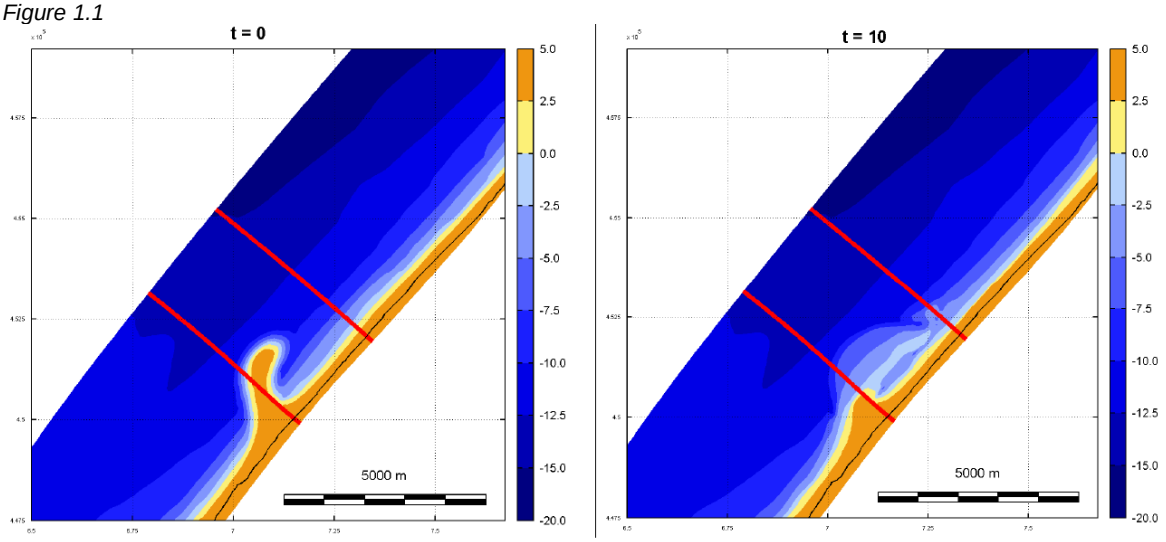
Contents

1 Plan of Approach

1.1 Context

Large parts of the densely populated areas of the Netherlands are located just behind the coastal defence. On a large scale, it is to be expected that sea level rises and land subsidence will increase. For this reason, there is a demand for structural nourishments of the Dutch coast. [Deltacommisie, 2008]
The sand engine is a project proposed by the province of Zuid Holland to prevent coastal erosion at a number of locations. At the moment small periodical nourishments are carried out to protect the coast from structural erosion at weak points in the coastal defence. The province proposed that these suppletions can be carried out more efficiently. The sand engine is a large-scale nourishment that will be redistributed by natural forces to achieve a gradual build out of the Dutch coast. This nourishment will be larger than currently needed but will make many of the smaller interventions obsolete.

Figure 1.1



A number of alternatives have been considered in the planning phase of the project. The final shape will be alternative “Haak Noord” [Projectnota MER zandmotor, 2009]. 20 million cubic meters of sand will be deposited just north of Ter Heijde, in front of the area of Solleveld. Using the forces present in nature, the sand is spread out along the coast.

1.2 Building with Nature

This master thesis is part of the research carried out by Ecoshape. The foundation Ecoshape is the main partner in the research program Building with Nature (2008-2012). This 30 milion euro program is initiated by the Dutch dredging industry, cooperating with a wide range of parties from the Dutch hydraulic engineering sector, like Deltares, Imares and the universities of Delft, Wageningen and Twente.
Building with nature is a long term research program that aims to develop knowledge for the sustainable development of coasts, deltas and river by combining practical hands-on experience with state-of-the-art technical en scientific knowledge on the functioning of the ecosystem and it interaction with infrastructures.

This approach is reflected in the five program objectives that were established for the program:

1. Develop ecosystem knowledge enabling Building with Nature
2. Develop scientifically sound design rules and norms
3. Develop expertise to apply the BwN concept
4. Make the concept tangible using practical BwN-examples
5. Establish how to bring the BwN-concept forward in society and make it happen

The core of the program is centered around four real-world cases (Holland Coast, Southwest Delta and the Marker- and IJssel Lakes in The Netherlands, plus case Singapore in a tropical environment). Generic research on governance-related topics and nature sciences is carried out by a group of 20 PhD researchers. *[Sustainable development of nourished shorelines: Innovations in project design and realization, S.G.J. Aarninkhof et al].*

1.3 Objectives

The goal of this research originates from the need to asses the effects and feasibility of the Sand engine or other mega nourishments. The current model of the sand engine based on Delft3D only takes in account the morphologic changes caused by waves and flow. Although these hydrodynamic forces cause sediment transports that reshape the sand engine, the contribution of the wind related sediment transports in the upper part of the sand body above sea level will also influence the evolution of the shape. The effect of aeolian transport can be considered local (hotspots of accretion and erosion, formation of young dunes on top of the sand engine) or on a larger scale (supply of sand from the beach/nourishment into the dune system). This makes aeolian transport an important factor to take into account with respect to the sediment budget of the coastal zone.

The main objective of this thesis is to produce a working numerical simulation of aeolian transport applied to the sand engine. An existing model will be used [Sauermann, Partelli, Herrmann 2008] to investigate the influence of erosion/shaping by wind. This study will try to investigate the working of the model and adapt or extend it for use at the Dutch coast.

A project like the sand engine has never been executed in the Netherlands, which makes the project an interesting pilot case also this makes forecasting a challenge. To judge if the model reflects reality, we need to be able to associate this type of model with our situation at the Dutch coast. Therefore, the model has to be tested in a reference case similar to the conditions at the sand engine. Based on these results, an assessment can be made of the accurateness and relevance of this model in our coastal area. A number of potential sites that can be used for validation are mentioned in Appendix I. It is proposed to do a number of test simulations before looking at the sand engine. This way experience with the software will be gained and certain aspects of the model can, if necessary be adjusted.

1.4 Aeolian transport model

There is still a knowledge gap with respect to wind driven sediment transport in a coastal system and presently aeolian sediment transport models are usually developed for areas like deserts. One of these models (called “Dune” of “xDune”) is the model of Sauerman, Kroy, Herrman and Parteli 2008. This model claims to be a minimal model for aeolian sand dunes. It combines an analytical description of the turbulent wind velocity field above the dune with a continuum saltation model that allows for saturation transients in the sand flux.

1.5 Research approach

To make sure that the numerical simulation has a solid (physical) foundation, factors that determine the sediment flux will be studied. This will be done in an extensive study of literature. The result will be an overview of physical parameters and there relative influence on the sediment transport model.
A second step is to investigate the model and identify which hypotheses and calculation methods are used. The xDune model is not a product of the TU Delft or deltares, there is no prior experience with this program so the content and the structure have to be examined if it is to be used properly.
If we want to use the model in this case (or other situations), it has to be determined if the program is applicable in various situations. In deserts, the model seems to work, but in our wet coastal system test cases have to be executed to prove the usefulness for the sand engine. The result of the runs using the reference cases have to be compared with the existing situations, analytical solutions or other models. While doing this, problems and differences will come up and have to be solved and processed in the model.
The next step is to set up the model for the case of the sand engine, this includes generating input like the bathymetry but more importantly is to determine the wind conditions an speeds that drive the calculation. After this, the results have to be analysed and judged if the outcome is plausible.
The final step is to incorporate the model into a model train consisting of several software packages like Delft3D, Xbeach and Unibest. The coupling of these tools is the subject of a master thesis that is carried out in the same time as this one. The purpose of this coupling is to produce a more accurate result and to have a better description of all the processes involved.

This subdivides the thesis in the following topics:

1 Literature review sediment transport by wind;
2 Research of the existing model;
3 Collecting data and set up test cases for the verification of the existing model;
4 Analyze results and compare with analytical solutions or other models;
5 Adapt existing model for the Dutch coastal case;
6 Set up model for case Sand engine;
7 Analyze results;
8 Implement results/numerical model into model train (Delft3D/Xbeach/UnibestCL);
9 Write conclusion and recommendations.

1.6 Project planning

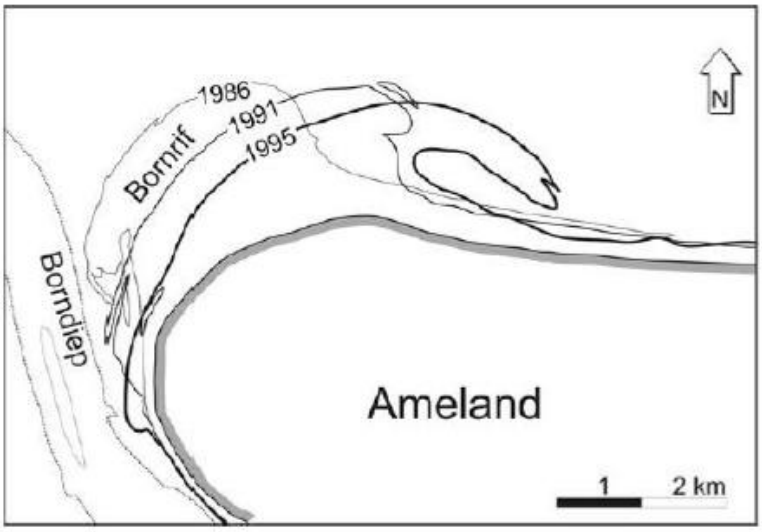
Global planning of the topics concerning this thesis:

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Write approach plan								
1) Literature review								
2) Existing model								
3) Test cases								
4) Analyze results								
5) Adapt existing model								
6) Set up sand engine								
7) Analyze results								
8) Implement results								
9) Write conclusion								

2 References

Deltacommissie. Working together with water. 2008
DHV. Projectnota/ MER Aanleg en zandwinning Zandmotor Delflandsekust. 2009
S.G.J. Aarninkhof et al, Sustainable development of nourished shorelines: Innovations in project design and realization. 2010
G. Sauerman & J. Herrman. A minimal model for aeolian sand dunes , 2002.
Parteli et al. Dune formation under bimodal winds. 2009

3 Appendix I: Potential reference cases

Zuid Holland, Vlugtenburg	
Ameland, Bornrif	

Zeeland, Kwade hoek	
Texel, De Hors