Sediment transport during the execution of the pilot nourishment Ameland Inlet

by

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Cover: Photo from hopper dredger Charlock, van den Herik, taken from the North Sea side
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Abstract

Introduction

The future coastal safety of the Netherlands - considering scenarios of relative sea level rise - requires a re-assessment of our current coastal maintenance. The current strategy of: 'Soft where possible, hard if needed', might not be maintainable in the future. Research program KustGenese 2.0 covers the study on how the Dutch coast can be maintained after 2020. A horseshoe shaped pilot nourishment of 5 Mm^3 on the outer delta of Ameland, at the edge of the Kofmansplaat, is created from March 2018 till February 2019. The objective is to create knowledge on ebb tidal delta behaviour and the applicability of new nourishment strategies. A large measurement campaign is set-up, of which the half yearly vaklodingen and 4-6 weekly surveys of the nourishment area give new insights into morphodynamic behaviour on the ebb delta.
This thesis covers a research to the sediment transport during the execution of this new type of 'system' nourishment. The knowledge of the dredging contractor van den Herik, the client Rijkswaterstaat[1] and research institute Deltares are combined to gain the best insight into the morphological development of the nourishment. This thesis is meant to form a basis for future research on the nourishment and the outer delta of Ameland.

Monitoring the behaviour of this nourishment is of importance for the 'learning in practice' goal of KustGenese 2.0, as well as learning as much as possible from the carried out nourishment. This analysis of surveys is rather time consuming to carry out, as an easy to use tool is demanded. The research question is;

How can the sediment transport during the execution of the pilot nourishment on the Ameland inlet ebb-tidal delta be described?

Natural behaviour Ameland inlet

To be able to examine the effects of the nourishment an extensive literature research is carried out, accompanied by a study of old vaklodingen. The 'Sand Hunger' of the Wadden Sea is partly the basis of this study, as the nourishment is located on the eroded outer deltas, which fed the Wadden Sea.
The development of the ebb shields on the outer delta, up until the nourishment was constructed, are of importance for determining the origin of sedimentation later on. The ebb shields, of which currently two are located on the ebb delta, show a similar clockwise rotation in time. A correlation between expansion speed and -direction and their location on the outer delta is clearly visible.
The latest half-yearly vaklodingen show a severe seasonal influence, indicating an important share of wave influence.

Tool for analysing dredging works

To describe and analyse the nourishment, a tool for analysing dredging works is developed. The tool is applicable for all kinds of dredging works, as is tested with other data. The tool combines the ships deposit data with survey and vaklodingen data. This combination of information creates a rich insight into morphodynamic behaviour during execution.
The tool is based on Matlab and QGIS software and creates; 2D and 3D charts and animations, difference charts, volume calculations and visualizes the ships deposits. It makes it easy to draw any cross section as well.
The tool is reviewed to be: 'An easy to use analysis tool, which makes a rich dataset quickly visible for analysis'.

Nourishment behaviour

Several analysis were performed by help of the developed tool. Wave conditions are the predominant physical process in the sediment transport on the nourishment. By bedform analysis it turned out that only directly at the end of the ebb chute a sediment transport direction towards the west exists. By cross sectional analysis, bedform analysis, and a numerical tracer study it turned out that the main sediment transport direction is towards the (south-)west. The magnitude of the nett sediment transport is completely depending on the wave intensity during the period. It must be stated that the wave induced transport is dominant for the nett displacements as it accelerates the process, but the shaping of the outer delta is caused by the (mainly ebb) tides.

[1] The Dutch Ministry of Infrastructure and Water Management. They are responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands.

Future system nourishments

During the execution there have been a lot of lessons learned. The change in design of the nourishment worked out successfully. The nourishment was placed on a little distance from the Kofmansplaat and as expected the 'trough' in between already (just after execution) largely filled up. The execution strategy in which the inner circle was constructed first, in summer, resulted in a better workability during high wave conditions in winter at the deeper outer circle. The distance at which the nourishment could be placed to be still dynamic enough to fulfil its functions could be a subject of future research.

Moreover the choice of the nourishment location has proved to be stable, but dynamic enough to learn from (at least till February 2019). In the coming years the effectiveness of this type of nourishments can be studied.

The translation from the nourishment to other deltas needs detailed knowledge of the new delta. The dominant transport of the location largely determines its behaviour, as the current position is largely influenced by wave action. If the nourishment would have been placed in front of the second ebb shield in the Ameland inlet, this behaviour would have been totally different as this is a ebb tide dominated location.