CHAPTER 152

SEAWARD COASTAL DEFENCE FOR THE DUTCH COAST

The Dutch coast : Paper No. 13

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1. INTRODUCTION.

The Dutch Delta-works are nearing their completion. Decades of construction of dikes and dunes come to an end. It is obvious that after the completion of these Delta-works, this infrastructure of coastal defence works needs its year to year maintenance as well. Therefore the Dutch Goverment asked for the so called "Coastal Defence study" and mobilized all the available kwowledge with respect to this item, in order to draft a report with which the political decisionmakers could come to the selection of the most suitable maintenance-strategy. Four different possibilities were investigated.

It appeared that the so-called full maintenance strategy will be the most cost effective and profitable solution and was therefore chosen. According to this strategy all retreat of the coastline will always be compensated (in general by beach-nourishment).

However, some parts of the Dutch coast are facing extreme erosion as well as very poor reserves and for those locations the application of a somewhat different approach can be profitable or (in time) even necessary (for instance with repect to sealevel rise). This approach was roughly investigated as the "Seaward Coastal Defence" strategy. According to this strategy additional measures will be taken to influence the morphological system in such a way, that the coastline will not erode any longer, but be kept on its place or even grow in seaward direction. The effectiveness of this approach has to be compared with maintenance by beach-nourishment as such as well as the effects it will have elswhere on the morphological system.

A pilot-study has been defined at the isle of Texel. The north-point of this island suffers severe erosion. Several beach-nourishments have been carried out here. Unfortunately the effectiveness was not always as planned.

This paper contains a brief description of the seaward strategy as such and more specific the preliminary results of the "Texel" pilot-study as obtained so far. In 1991 the finite conclusions will be available.

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2. SEAWARD COASTAL DEFENCE STRATEGY.

In the Coastal Defence study four strategies have been worked out, respectively retreat (only the real hot spots will be maintained for safety reasons), partially maintenance (also some other uses of the coastal zone can be a reason for maintenance), full maintanance (all retreat of the coastline will always be repaired) and "seaward".

The seaward-strategy aims permanent reinforcement of the weakest, heavy eroding spots along the Dutch coast by "changing" the erosion into a more or less stable situation or even sedimentation. In order to start this process, it is necessary to influence the (large scale) sand-transport phenomena along the Dutch coast. The placement of an initial construction will be the driving force behind this "sand-trapping" process. Because of the difference between the several morphological systems along the Dutch coast, it is not possible to suffice with one solution. Therefore for each of the hot spots specific solutions have been created (tabel 1 and figure 1).

name	aim	construction
Texel	creation of sedimentation along eroding coast. sedimentation, (partially)	large dam, perpendicular to the coastline. In case of to large timescale for natural artificially nourishment to an extended beach.
N.Holland	creation of sedimentation along eroding coast	one or two large dams, perpendicular to the coast-line. In case of to large a timescale of sedimentation, artificial placement of sand in the shape of a beach or barrier with a lagoon.
Voordelta	reduction of wave attack	artificial initial raise of sandbanks with ridges of stone or "sand-sausages", stimulation of sand accumulation with artificial seaweed, creation of sand-drift.
Walcheren	prevention of progression erosion by currents	two or more dams to shift currents. Stimulation of sedimentation in an enclosed area.
Cadzand	prevention of negative effects "sandwaves"	sub-merged dams between the groynes. Pending beach.

tabel 1 : possible "seaward" solutions for the Dutch coast

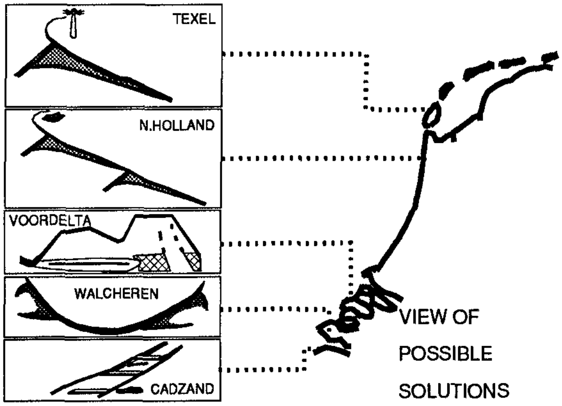

figure 1 : view of possible solutions for seaward defence

These scetches are of an preliminary status. They are based on many assumptions and with respect to several items, further research will be necessary. Therefore Rijkstwater-staat has decided to start a pilot study.
The most likely location for such a study has been found on the heavily eroding northern point of the isle of Texel.

3. THE "TEXEL" PILOT-STUDY.

The pilot-study concerns the hydraulical and morphological background of the erosion at the north part of the isle of Texel, the layout and construction of some solution(s) and determination of its effectiveness from morphological and economical point of view. These solutions have to be compared with the present way of coastline maintenance i.e. beach-nourishments.

3.1 large scale morphological behaviour.

With respect to the large scale sand transport phenomena, the following remarks can be made. Along the Northsea-coast of the isle of Texel sand is transported in northern and southern direction to the Robbengat and the Molengat (fig. 2) due to the combined effect of longshore and tidal currents. This results in a net loss of sand in the direction of the Wadden-sea.

The Delta between the isle's Texel and Vlieland does show a clear system of eb-tidal channels ("Eierlandse Gat"). The system of flood-tidal channels is far less developed. Both types of channels play its role in the transport of sand in the direction of the isle of Vlieland. Some sand is transported directely along the sea-ward boundaries of this delta due to wave-action.

Some sand is trapped into the so called Slufter, an intertidal area behind the dunes just above the center of the island.

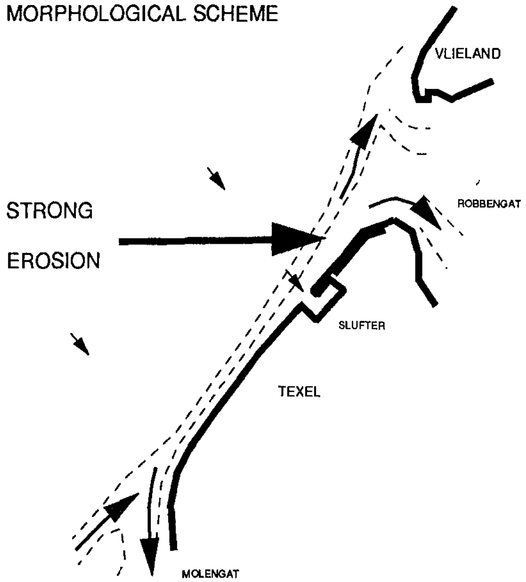

figure 2 : morphological scheme.

From the south the coastline of the island is supplied with sand from the delta between the coast of North-Holland and Texel ("Zeegat van Texel")

Due to cross-shore transport some sand is supplied from deeper water to the coastal zone. This quantity is believed to be of minor importance compared to the mentioned longshore processes.

All this moving sand can not prevent that the entire coastline of the island retreats. In the center of the island this retreat is 1 to 5 meters per year, increasing in northern and southern direction up to 20 meters per year and even more. At some places a retreat of even 30 meters in one year has been occurred.
Predictions have been made, and if nothing would have been done, the coastline north of the Slufter would show an average retreat of 100 to 150 meters for the next ten years (fig. 3).

A retreat like that is absolutely not acceptable for reasons of nature and shipping traffic (a lighthouse is standing close to the edge). Therefore beach nourishments have been carried out.
Upto now in 1979 (3 * 10^6 m3) and in 1985 (2.8 * 10^6 m3) along this stretch and in 1984 3 billion m3 along the middle of the island. This year the nourishment of 1985 had been disappeared completely. Some parts of the coastline retreated even much further. At present a nourishment is carried out.
The problem with nourishments along this coastline is, that in fact there is not enough

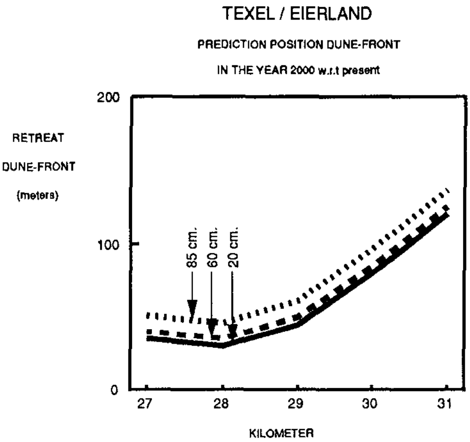

figure 3 : prediction position of dunefront

space to place the sand in such a way that it will not be eroded directly at the toe by tidal currents (fig. 4). From economical point of view, reduction of quantity is therefore needed or the use of coarser material. The latter solution was chosen for the nourishment of this year.

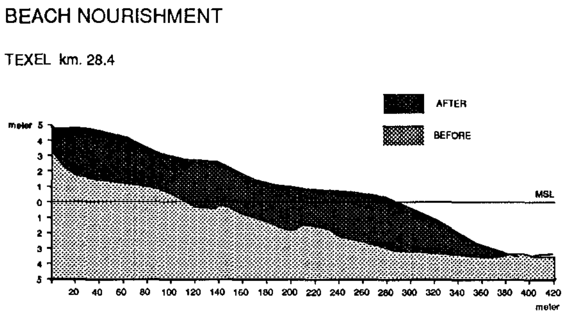

figure 4 : cross-section beach nourishment 1979

3.2 small scale morphological behaviour.

The coastline of Eierland (north of the Slufter) looses a quantity of sand with an average of 400.000 m3 to 500.000 m3 per year (fig. 5). These figures were valid for the "undisturbed" situation, so before the first nourishment had been carried out. Since then these figures have increased (to 600.000 m3 per year) due to the effect mentioned earlier i.e. the lack of space for placing the sand without coming under the direct influence of the tidal currents. As stated before, these quantities are average values and will vary from year to year.

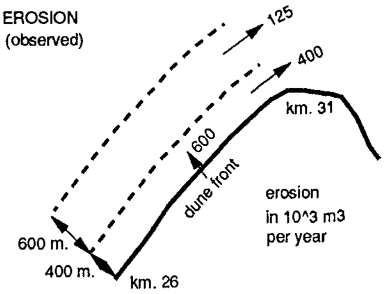

figure 5 : erosion quantities (observed).

These quantities have been established from the yearly soundings of the coastal zone (JarKus = Jaarlijkse Kustmetingen). These soundings have also been used for the analysis of the development of the cross-shore profiles. From this it can be concluded that two different zones can be distinguished. A zone of about 400 meters from the dune-foot with a rapidly changing bottom-topography, followed by a zone of about 600 meters seaward with a rather flat and stable topography.

In the autonomous situation in the first zone the loss of sand amounts approximately 400.000 m3 per year and in the second zone approx. 125.000 m3 per year. After the first nourishment the figure for the first zone increased to about 600.000 m3 per year, whereas in the second seaward zone a sedimentation of about 100.000 m3 per year was established soon after the works had been completed. However, this was only for a short time. Soon erosion also started here again.
Apart from these figures obtained from measurements, also calculations with relatively simple mathematical models were made on a personal computer. The aim of these calculations was to investigate the different contributions of the transport phenomena with respect to the observed processes.
Calculations were made with respect to wave-height, wave setup, longshore currents and tidal durrents, sediment transport (several approaches), dune erosion, etc. It appeared that each of the components could be obtained rather well, compared to the available data. For instance the transport capacities due to the differences in wave setup along this coastline could be chequed with tide gauge measurements under storm conditions.
The following contributions to the total erosion due to transport-capacities were calculated (fig. 6) :

* 60 percent due to waves and currents under normal, “average” conditions;
* 20 percent due to tidal currents without wave-action;
* 20 percent due to differences in wave-setup under storm conditions.

This last figure, the 20 percent due to differences in wave-setup under storm conditions, could seem to be of minor importance, but it should be stated that under these circumstances the eroding sand from the dunefront will be transported directely from the coastal zone to elsewhere and does not supply the foreshore. Therefore it will not contribute to the reduction of dune-erosion under these circumstances and will also not be available for the natural restoration processes afterwards.

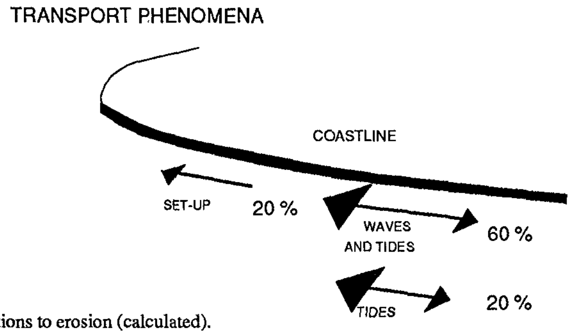

figure 6 : contributions to erosion (calculated).

3.3 next fase of the study.

The first phase of the study was directed to the establishment of the erosion quantaties and the phenomena responsable for this erosion. A first order approach appeared so far to be sufficient. This phase has come to an end now.

In the next phase more detailed research will be carried out with respect to those phenomena that appeared to be of vital importance for the development of this coastline. Therefore, a detailed mathematical model shall be made with respect to the tides (currents and elevations) in the whole area. This area includes the tidal-basin, the entire delta's and large parts of the adjacent coastlines (both islands). After tuning this model, different types of solutions to the problem will be brought in. The effect of each of these possibilities to the hydraulics can then be calculated.
From there it will be decided whether further modelling with respect to waves and sandtransport will be necessary. If so, the necessary models shall be build.

3.4 proposed solutions.

One can think of many solutions to this problem. However, it is of utmost importance that the solution chosen, will not have any negative effect elswhere. Therfore one should be very carefull.
This could lead to the conclusion that for instance a solution with a long, "sand-trapping" dam will not be the answer. In general these harbour-mole like constructions do stimulate sedimentation on one side, but one should be very carefull with the possible

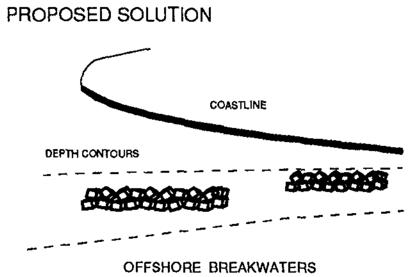

figure 7 : proposed solution

effects due to the erosion on the other side. Especially in a sensative morphological system like this.

It is more likely that a solution with two or three offshore breakwaters will be much better. Wave-attack on the coastline will be strongly reduced and it must also be possible to influence the tidal current in such a way that its transport capacity in the coastal zone will deminish significantly.
Pleasant features of this solution are the possibility of adaption after construction and the possibility of construction in different phases. So, in its way it is a "flexibel" solution and offers several possibilities of tuning to the morphological system. Along the Channel-coast in the northern part of France such a construction appeared to be very succesfull.

4. CONCLUSIONS.

* from now on, the Dutch coast will be kept on its place according to the full-maintanance strategy;
* the most suitable way to do so, is the placement of beach-nourishments;
* some places facing extreme erosion and/or very poor reserves a different, seaward strategy can be necessary;
* according to this strategy, initial measures will be taken to influence the morphological system in such a way, that retreat of the coastline will change into a more or less stable situation or even accretion;
* one of these places is found on the isle of Texel. A pilot study is carried out;
* each of the components behind the total erosion process has been established by analysis of measurements and first order approach calculations;
* 60 percent of the erosion takes place due to average wave and tide conditions, 20 percent due to tides alone and 20 percent due to differences in wave setup under storm conditions;
* more detailed research will be carried out, to start with a mathematical tidal model for the entire area;
* the construction of two or three offshore breakwaters looks to be the most promissing solution to the problem;
* in 1991 all finite conclusions and designs will be available.

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