

CHAPTER 49

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

Johann Kramer
Regierungsbaurat
Forschungsstelle Norderney
Norderney, Germany

INTRODUCTION

The Island of Norderney is one of the East-frisian Islands, situated at the southern coast of the North Sea (Figure 1). It arose out of the sea, which will say that it is not the remainder of an old mainland. In the beginning there was a shoal, moulded by tide currents and wave action where later on various plants enabled the growth of sand dunes. The East-frisian Islands are supposed to exist since more than 1000 years already. But the written history dates back as far as to the 14th century only. From charts and other historical documents we know in which way these islands changed during the centuries. Some islands vanished whilst others only changed their positions.

At the beginning of the 19th century, when Norderney became a seaside resort, the village was still protected by a wall of sand dunes against the assault of the open sea. In the course of time, however, the western part of the island got lost by erosion and the sand dunes were destroyed (Figure 3). When in the middle of the nineteenth century the seaside resort, which had grown larger and larger in the meantime, threatened to be attacked by the sea, people began to protect their island. In the year 1856 they had built a seawall to the length of 900 metres. As at its ends the dunes were still destroyed, this revetment had to be extended. Moreover groynes had to be built to prevent the development of narrow channels in front of the seawall, which might have caused its destruction. Thus in the course of nearly 100 years the revetments as shown in figure 2 were founded.

There are now nearly 6 km of seawalls of different types. In former times the walls were built much steeper than now-a-days. The groynes changed their shapes as well. The building material altered according to the respective level of technology. Material applied was wood, stone, concrete as well as steel and asphalt.

During the years 1940 to 1948 the revetments could not be maintained. The beach had lost much of its height. Therefore the seawalls and the groynes were to a high degree exposed to the violent attack of the waves. In order to avoid further destruction something had to be done. The protection works represented at this time investments of a value of about 40 million DM. After various inquiries had been started, a filling of the beach seemed to be the most profitable way.

COASTAL ENGINEERING

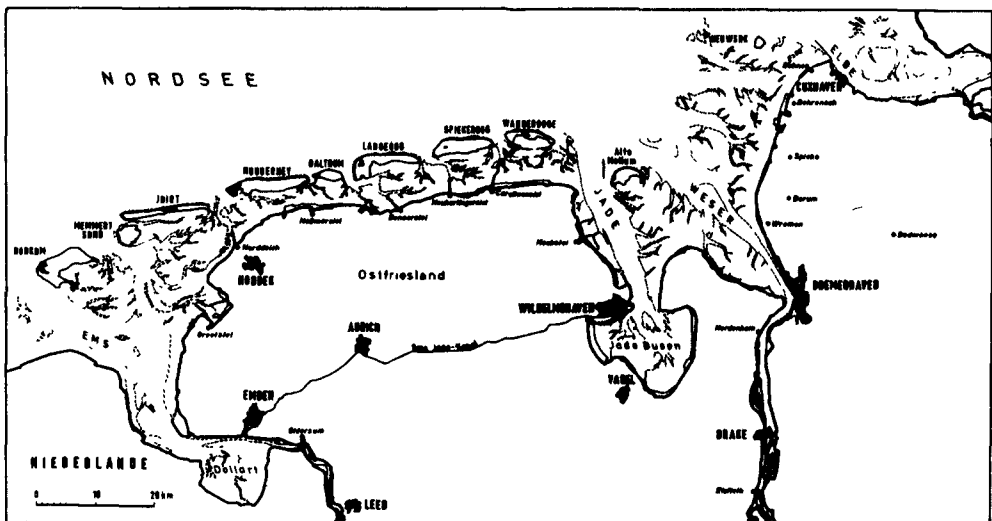


Fig. 1 Location map.

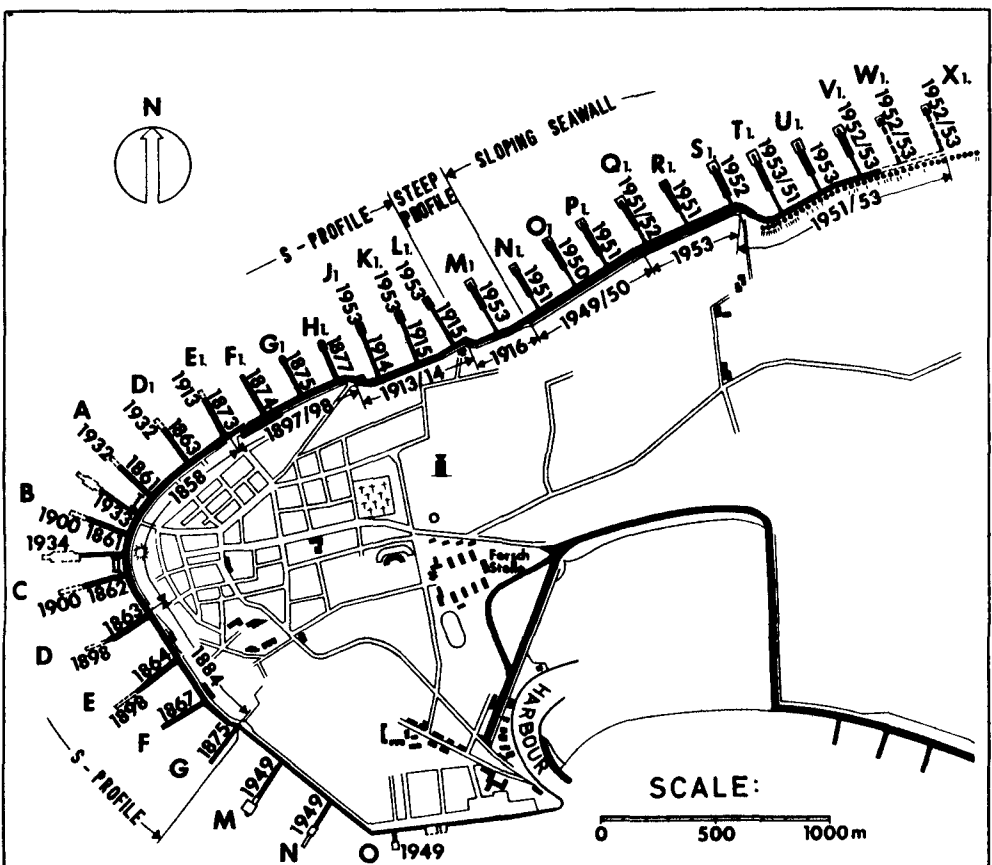


Fig. 2 Development of the revetments on Norderney.

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

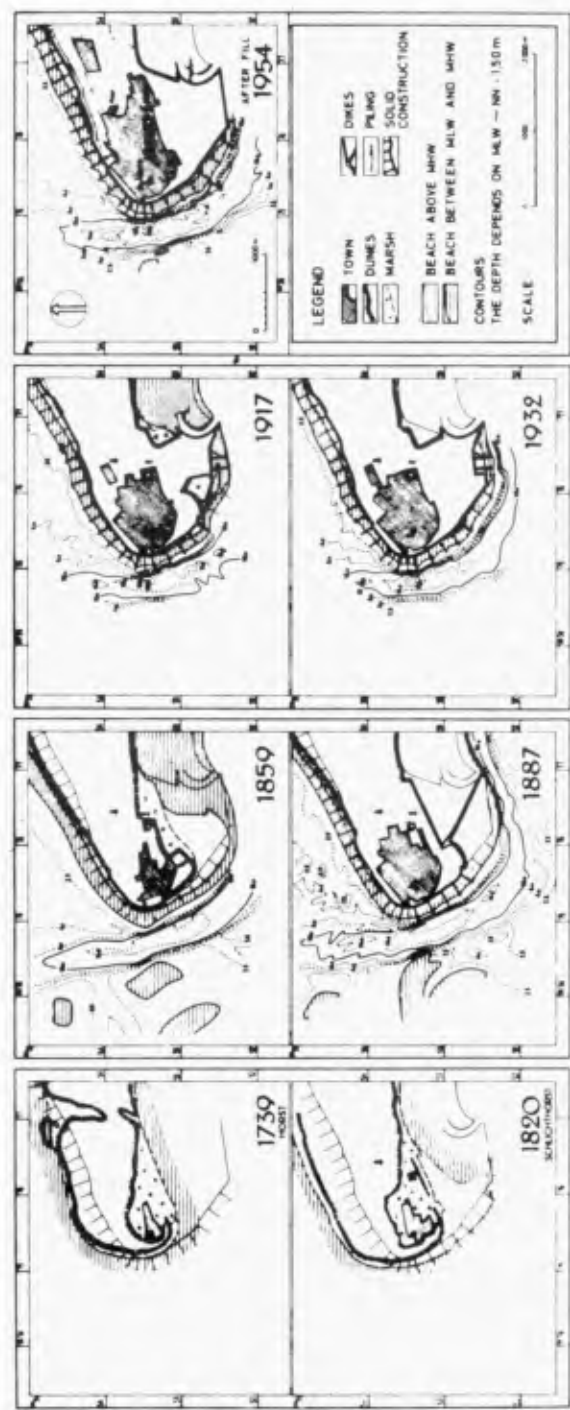


Fig. 3 Development of the beach at the western part of Norderney 1739 - 1954.

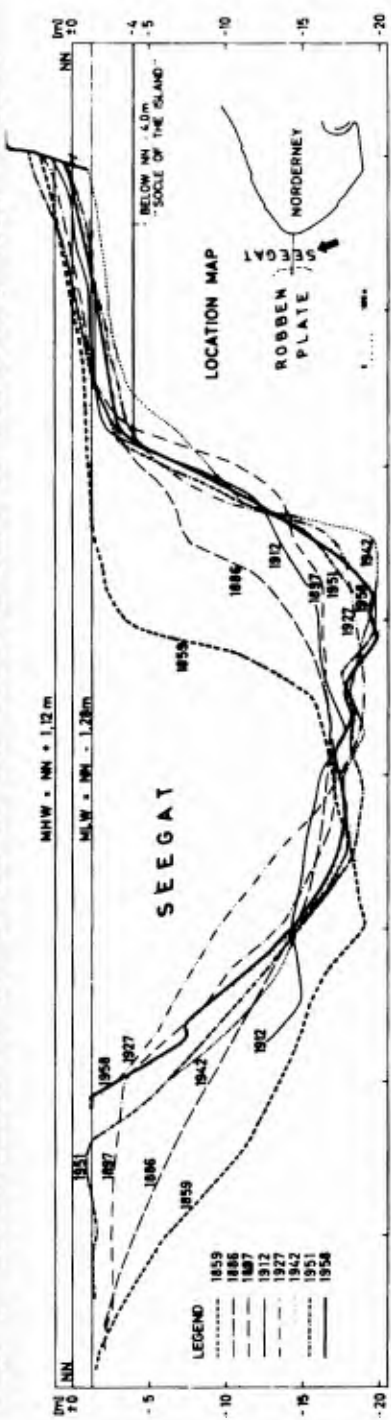


Fig. 4 Development of the profile across the "Norderneyer Seegat" from 1859 - 1958.

COASTAL ENGINEERING

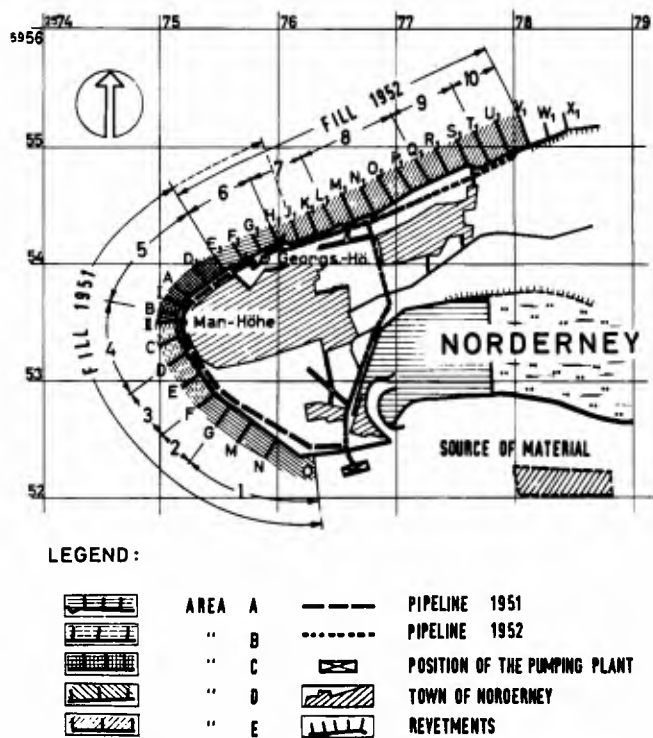


Fig. 5. Fill 1851/52. Location map of the source of material, of the pump- ing plant with the pipeline, and of the areas 1 to 10 of equal development.



Fig. 6. The beach after the 1951 fill at the western part of Norderney.

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

THE FILLING OF THE BEACH 1951/52

QUANTITY OF SAND NECESSARY AND TECHNICAL WAY OF TRANSPORTING IT

The beach fill of Norderney entirely differs from the traditional way of protecting islands by seawalls and groynes. The idea of filling the beach was rather extraordinary - even to a great number of experts. The success was expected to be limited, because the natural powers remained dominant. Their destroying effects could only be lessened but never eliminated or overcome. The filling of beaches was something entirely new at the German coast.

In order to evaluate the quantity of sand necessary for filling the beach, the surveys of the beach from 1897 to 1950 were considered. Those were the years when long groynes had begun to stabilize the foot of the island (Figure 4). 1.077.000 m³ of sand had been carried off during the years 1930 to 1950 above 5 m below mean level. After the filling the estimated yearly loss of sand would run up to about 90.000 m³. It was necessary to restore the beach to the height of 1900. About 1.240.000 m³ sand were needed for this purpose. Nearly 1.550.000 m³ of sand had to be dredged adding a certain quantity which would be lost during the transport and the filling process.

The sand was dredged by two bucket dredgers south-east of the harbour (Figure 5) and transported with barges to the pumping plant where mixed in the proportion 1 : 6 sand and water were pumped through a discharge pipe having a diameter of 60 to 70 cm. In order to reach the farther places - about 5 km distance - a booster pump was necessary.

Soon the most suitable way of filling the beach between the groynes was found out. The mixture of sand and water was let out of the pipe mouth coming down from the revetment. When the intended level at the low water line was reached, a device was applied which spread the pumped soil over the whole breadth of the beach between the groynes. Thus the area was equally filled and soon a 100-metre-wide beach above high water level was completed (Figure 6). During the following winter it was lost already, because the destroying influence of the littoral current was far too strong.

THE DEVELOPMENT OF THE BEACH 1951/52

Before the fillings were started, careful observations of the beach were undertaken. Afterwards the following observations were regularly repeated:

1. Surveys of the beach and foreshore down to below mean level.
2. Annual photos of the beach in fixed directions.
3. Analyses of the grains of sand taken from around the

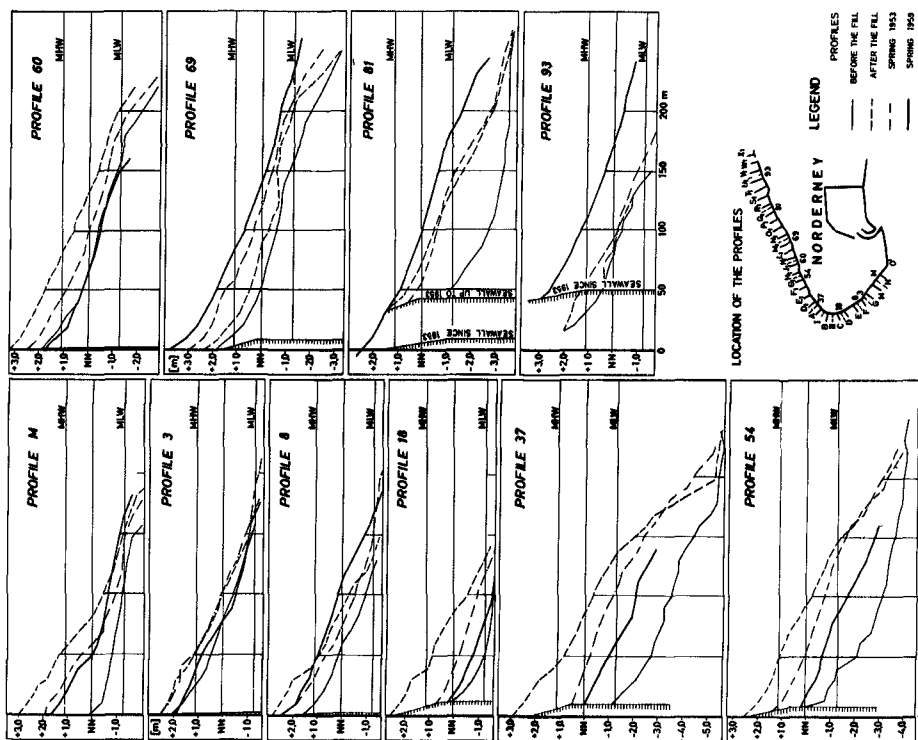


Fig. 8. Change of the beach profiles from after the fill 1951/52 to 1959.

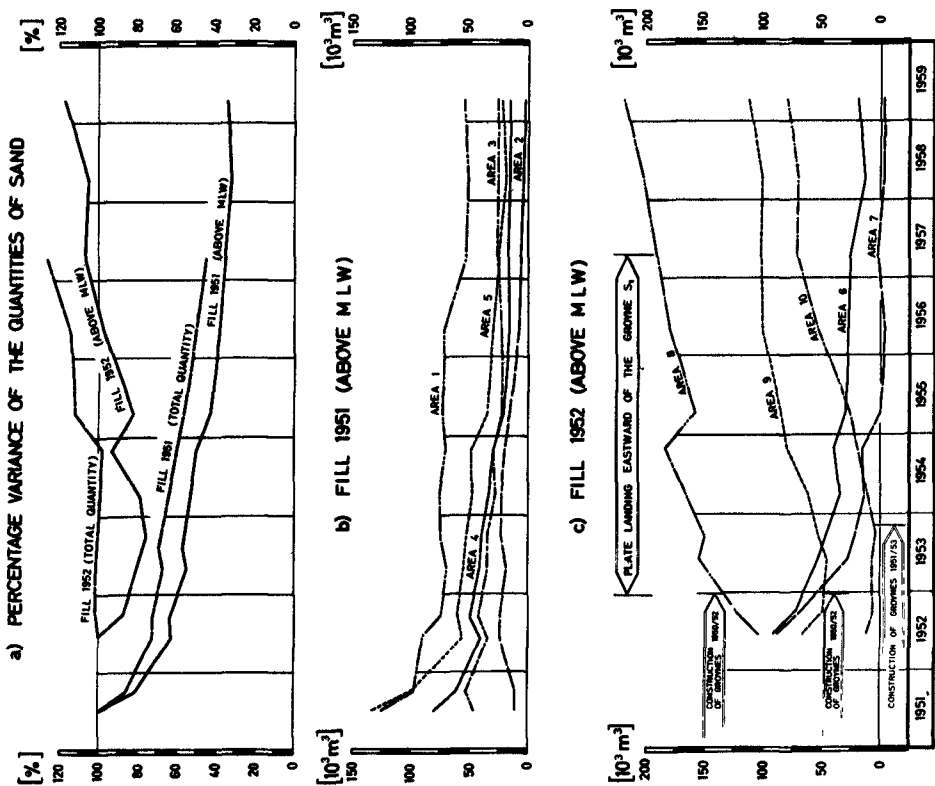


Fig. 7. Change of the quantities of sand on the beach after the fill 1951/52

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

dredging area and from the beach after the filling.

The filled beach areas can be divided into areas of equal development. The entire quantities of sand brought on to the beach are as follow:

Area of filling 1951:	1.050.000 m ³
Area of filling 1952:	770.000 m ³ .

In figure 7 the results of the calculations for the quantities of sand are represented:

a) The percentage development of the filling 1951 and 1952. The quantity of sand that had been left within the area 1 to 5 as well as 6 to 10 immediately after the filling have been regarded as 100%.

b) The change of the quantities of sand within the areas 1 to 5 in absolute figures.

c) The change of the amount of sand within the areas 6 to 10 in absolute figures. Moreover the period of the landing of the sandbank at the northern beach as well as the completion of the groynes in the areas 8 to 10 have been recorded in order to recognize their influence on the development of the beach.

This representation shows that, in the beginning, the fill 1951 has been carried off much more quickly than later on. During the first weeks and months the unnaturally steep beach above mean level which was highly exposed to the attack of the wave action decreased to a large extent. Since 1953 an almost uniform decrease of the beach was observed. There has always been a difference between the development in summer- and wintertimes during the last years.

In the years meanwhile gone by, the filled beach has developed in different ways. In the area of the filling of 1951 nearly 34% of the material above the mean level were still left. The large increase of sand in the areas 8 to 10 is not necessarily the consequence of the filling but refers to a sandbank which landed there at the same time. Besides that the achievement of the groynes must be considered. It is easily recognized that the increase of the beach starts as well with the beginning of the landing of the sandbank in the areas 8, 9 and 10 as with the approximate completion of the groynes. Therefore it is impossible to discriminate the influence of the landing of the bank and the effect of the groynes from the development of the eastward beach. To separate these two factors will be possible only in the course of several years, when the effects of the last landing of the shoal will be gone or when perhaps a new one will have appeared. Till now it was not possible to see a relation between the tidal effects and the erosion of the beach.

COASTAL ENGINEERING

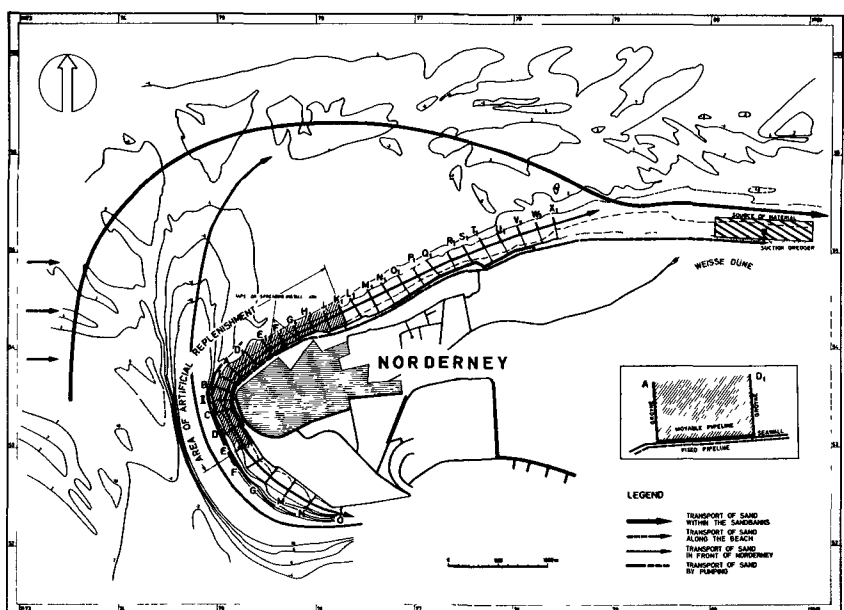


Fig. 9. Natural movement of the sand in front of Norderney and artificial transport at the northwestern part of the island.

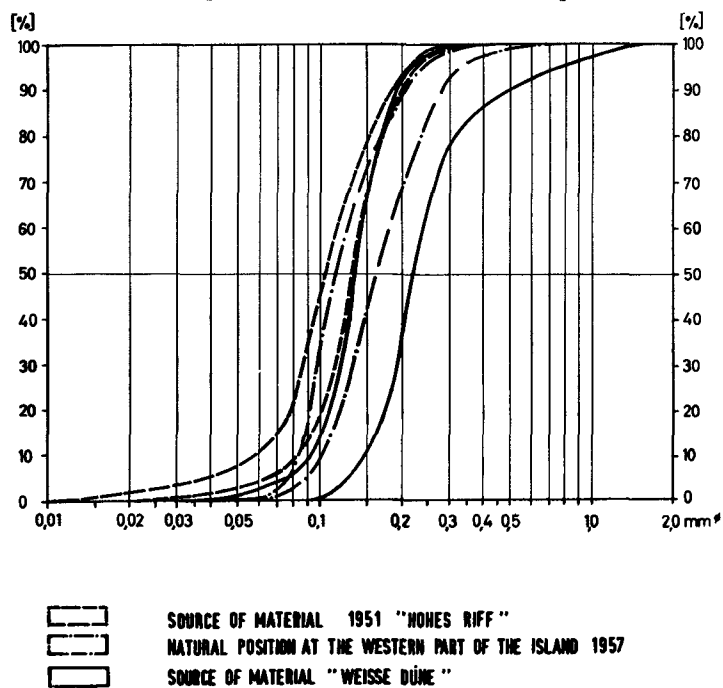


Fig. 10. Size of the sands.

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

Some of the beach-profiles measured once a year that are characteristic for certain areas are shown in figure 8. They represent the beach-height in 4 different periods:

1. Beach-height before the filling,
2. Beach-height after the filling of 1951/52,
3. Beach-height in spring 1953, after large quantities have been carried off from the unnaturally high beach,
4. Beach-height in spring 1959.

By means of samples the variations of the grain composition of the filled material could be defined. Two months after the filling the finer material had been washed out already. In summer 1957 the composition of the material did no more differ from that of the natural beach.

THE RESULTS OF THE BEACH-FILL 1951/52

The summarized results are as follow:

In 1951/52 a quantity of $1.816.500 \text{ m}^3$ of sand was filled in between the groynes 0 to V1, the beach gained the amount of $1.245.500 \text{ m}^3$, 571.000 m^3 were lost during the filling, the loss amounts to 31%.

The expenditure of 3,5 million DM for the fill of the beach compared with its efficiency results in a full success, technically as well as economically. On the whole it is a profitable way to protect the island.

A certain loss of the filling material had to be considered in any case, for the natural powers could not be influenced by the fill. In fact the annual loss diminishes with the decrease of the beach height. With the present height, however, a limit is reached below which the seawalls are no longer sufficiently covered with sand. This state demands a decision about future protection works.

THE PLAN OF A CONTINUOUS FILL

INTENSIFICATION OF THE INSUFFICIENT NATURAL SUPPLY OF SAND BY ARTIFICIAL MEANS

Beach stability is possible only, when the supply of drift sand and of eroded material is balanced. In front of Norderney the littoral drift is insufficient. It takes its way as demonstrated in figure 9. The eastward drifted sand moves towards the sea inlet in front of Norderney, where it is directed into a curve within the belt of shoals. The direction of the littoral drift is a result of the tide-currents along the islands which are mainly west-eastward directed and of the

COASTAL ENGINEERING

ebbstream in the deep channel in front of Norderney which turns northward. The sand from the belt of shoals is drifted towards the northern beach of the island about 3,5 km eastward of the western point. A great portion of it is transported to the east by the tide-currents and the wind, the remainder moves towards the western groynes H1 - J1. This supply is not nearly sufficient to balance the loss caused by erosion. The beach following westward is losing sand by erosion permanently, because the quantities arriving from the belt of shoals are too small to compensate the eroding material.

After the revetments had been built, the dunes were saved from further destruction. Since 1900 especially long groynes helped to stabilize the foot of the island below - 4 m mean level. The beach above this line up to the toe of the seawall could not be held, because the groynes did not show the expected efficiency in the area where the sand is carried off mainly by wave action.

The bases for an artificial fill are these:

1. The sand from the littoral drift along the coast moves eastward towards the eastern end of the revetments.
2. The accretion at the beach of the western part of Norderney is not nearly sufficient to balance the decrease there. The beach erosion is limited to the area from the toe of the seawall down to the line of 4 m below mean level.
3. The sand material eroding from the beach is transported to the belt of shoals and from there to the eastern part of the island. If the sand from the accretion area were pumped to the eroding areas, a circulation could be achieved.
4. In order to avoid that the decrease of the beach becomes still greater than it is now, the revetments must necessarily be kept in the present state.

QUANTITIES OF MATERIAL NECESSARY FOR A FILL

From the results of the filling 1951/52 we can see that in order to reach a worthwhile stability by an artificial fill the following points must be considered:

1. The grain of the sand must be equal or even coarser than that of the natural beach. The coarser the grain is, the more slowly will the eroding effects come into action.
2. The beach must not be higher than necessary for its task, so that the erosion caused by high tides is the lowest possible.
3. The incline of the filled beach should correspond with that of a natural beach in order to avoid unnecessary decrease.

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

The place from where the sand is to be taken for future fills (Figure 10) belongs to an area where the sand on an average has a coarser grain than that of the beach which is to be filled.

From experience gained by the beach-filling 1951/52 we learned that highly raised beaches which in conclusion will have an extraordinarily high decrease can be avoided, when the artificial fill is not done in long intervals, because this accomplishment demands a relative high fill to balance up the high cost related to a replenishment of this kind. When the beach is filled every year, so that its height is sufficient to protect the island, the decrease can be kept down to a small extent.

The movement of sand at the beach after the fill 1951/52 can be used as a foundation to find out the most suitable height of the beach. The height in spring 1953 should be sufficient, for it meets the following conditions:

1. At the western and the north-western beach of the island, where an artificial fill is needed, the toe of the seawall and the groynes were sufficiently covered with sand to fulfill its protection purpose.
2. The incline of the beach is nearly the same as the natural one.
3. The height of the beach at the toe of the seawall is below normal high-tide, so that the decrease of sand caused by wave-action is kept down, even when the tide is raised by a storm.

Another reason why the height of the beach of 1953 is so favourable is the fact that from 1953 the decrease of sand is almost uniform every year. On an average the loss from 1953 to 1957 amounted to about 53.000 m^3 at the areas 1 to 6 which needed replenishment. If this quantity of sand could be refilled every year, it is probable that within limited oscillations caused by the change of meteorological conditions the beach might be kept at a permanent height. An increase of 60.000 m^3 of sand annually would be sufficient.

A certain loss during the refill must be considered, because a part of the mixture of sand and water spread on to the beach moves immediately off towards the sea. Experience shows that this loss will run up to about 35%. Consequently 80.000 m^3 of sand would have to be transported every year.

An annual amount of 80.000 m^3 would be most suitable, because this quantity could easily be managed by a permanent pumping plant which must always be ready for action to balance a sudden decrease of sand, for, as soon as the idea of installing a permanent pumping plant has become reality, the security of the island would depend on the artificial replenishment of

COASTAL ENGINEERING

the beach.

The sand will be derived from the east of the island where permanent natural accretion is given. This accretion amounts to at least 130.000 m³ yearly - probably even 250.000 m³.

The material transported from east to west erodes and moves back to the belt of shoals and finally reaches its source again (Figure 9). Thus a new circulation is created, which runs beside the vast movements of large sand-masses in the sea in front of Norderney. It is not likely that the artificial decrease of sand will have any bad influence on the eastward beach areas, for the quantity needed every year is only a small portion of the sand derived from the belt of shoals. In order to reach the beach height of 1953 again, which should be the aim of the continuous fill, it will be necessary to transport more than 80.000 m³ during the first years.

Practice will at all events differ from theory. Today we cannot tell, but the quantity necessary might be much lesser than estimated, because the sand for future fills will be much coarser than the material on the beach to be filled. This fact seems to be an important factor to slow up erosion.

The technical construction of the pumping plant cannot be detailed here. It is true that beach-fillings with the aid of pumping plants are most favourable. The sand might be won with a scraper or a suction dredger. Four booster-pumps will forward the material from the scraper or suction dredger to the western part of the island.

By the way of continuous working the process could be automatized to a high degree, so that the number of workers and consequently the costs could be kept down to a reasonable level. The costs of a fixed establishment are low in comparison with other propositions concerning the permanent security of the island.

REFERENCES

- Akkermann, M. (1956). Die Umlagerungen des Sandes im Seegebiet vor Norderney und auf der Insel: Jahresber. 1955, Bd. VII, Forschungsstelle Norderney.
- Arbeitsgruppe Norderney des Küstenausschusses Nord- und Ostsee (1952). Gutachtliche Stellungnahme zu den Untersuchungen über die Ursachen der Abbruchserscheinungen am West- und Nordweststrand der Insel Norderney sowie zu der zum Schutze der Insel vorgeschlagenen bautechnischer Maßnahmen: Jg. 1, H. 1, Die Küste.
- Forschungsstelle Norderney (1949). Die Ursachen der Abbruchserscheinungen am West- und Nordweststrand der Insel Norderney und die Beurteilung der zum Schutz der Insel

BEACH-REHABILITATION BY USE OF BEACH FILLS AND FURTHER PLANS FOR THE PROTECTION OF THE ISLAND OF NORDERNEY

vorgeschlagenen bautechnischen Maßnahmen: Jahresber. 1949, Bd. I, Forschungsstelle Norderney.

Fülscher (1905). Über Schutzbauten zur Erhaltung der ost- und nordfriesischen Inseln: Berlin.

Gaye, J. (1934). Entwicklung und Erhaltung der ostfriesischen Inseln: H. 22, Zentralbl. d. Bauverw.

Gaye, J. und Walther, F. (1935). Die Wanderung der Sandriffe vor den ostfriesischen Inseln. H. 41, Die Bautechnik.

Gaye, J. und Walther, F. (1929). Bericht über Schutzbauten zur Erhaltung der ostfriesischen Inseln Juist, Norderney, Baltrum, Langeoog und Spiekeroog in der Zeit von 1900 bis 1928: Norden/ Norderney.

Hannoversche Versuchsanstalt für Grundbau und Wasserbau (1957). Modellversuche für die Verlängerung der Buhne E.

Homeier, H. und Kramer J. (1956). Verlagerung der Platen im Riffbogen vor Norderney und ihre Anlandung an den Strand: Jahresber. 1956, Bd. VIII, Forschungsstelle Norderney.

Köritz, D. (1954). Quantitative Untersuchung der Wasservertriftung über das Juister Watt: Jahresber. 1954, Bd. VI, Forschungsstelle Norderney.

Kramer, J. (1957). Künstliche Wiederherstellung von Stränden unter besonderer Berücksichtigung der Strandaufspülung Norderney 1951/52: Jahresber. 1957, Bd. IX, Forschungsstelle Norderney.

Kramer, J. (1954). Die Auswirkung der Inselfschutzwerte auf die Strandentwicklung im Westteil von Norderney: Jahresber. 1954, Bd. VI, Forschungsstelle Norderney.

Peper, G. (1955/56). Die Entstehung und Entwicklung der Inselfschutzwerte auf Norderney mit besonderer Berücksichtigung der Bauten der letzten Jahre: Bd. 8, H. 3, N. Arch. Niedersachsen.

Thilo, R. und Kurzak, G. (1952). Die Ursachen der Abbruchserscheinungen am West- und Nordweststrand der Insel Norderney: Jg. 1, H. 1, Die Küste.