CHAPTER 34

THE TERMINAL PROBLEM IN COAST PROTECTION

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ABSTRACT

This paper introduces the terminal erosion problem which usually occurs down drift of coast protection works, an important aspect of coast protection which is often overlooked.

To provide the background to this problem, the formation, replenishment and function of a natural shingle beach is discussed in relation to coast protection. The value of groynes in stabilising the foreshore, the use of artificial beach replenishment, and the effect on the long shore regime following the introduction of a sea wall, are discussed in outline with typical examples.

Terminal erosion is described in more detail, with reference to its cause, and illustrated by examples taken around the coast of the British Isles. Suggestions are made for the investigation of the terminal problem, design considerations are discussed, and terminal groynes and various types of terminal works described. Particular reference is made to the permeable type of terminal section.

Finally the paper is illustrated by examples of terminal works which have been constructed at two sites in this country. The foreshore conditions and exposure are described, together with the details of the sea wall and groynes, and the details of the terminal works at each site.

NATURAL COAST PROTECTION

Along many hundreds of miles of the coastline of the British Isles the adjoining low ground is protected entirely by natural ridges of sand and shingle. The formation and replenishment of these natural ridges depends on the supply of material available, the tidal levels, and the characteristics of the waves reaching the foreshore.

During calm weather the swash from the long, low, constructive waves breaking on the foreshore carries the beach material up the slope, and then, depending on the permeability of the slope, the backwash returns seaward beneath the surface leaving the suspended material higher on the slope. The profile of the foreshore and the height of the ridges or fulls varies from tide to tide, as the beach material is redistributed both across and along the foreshore. During storms the beach material absorbs the greater energy of the higher, steeper, storm waves, and becomes redistributed across the foreshore. Some is thrown into ridges well above the normal level by the destructive waves, but much is raked down the foreshore and deposited further seaward to await the next calm period. The beach material thus provides a continuous natural mantle of protection as it moves along the coast. A good example of this on the South Coast of England is the Chesil Bank, a shingle bank which extends for a distance of 30 kilometres and rises to a height of 15 metres above the mean sea level at the Eastern end.

However, where a natural headland or an artificial obstruction retains part of the drift material, there is a reduction in the volume of littoral drift passing that point, and the coast beyond is starved of beach material.

GROYNES TO ASSIST A NATURAL BEACH

If there is still a sufficient supply of littoral drift along the foreshore, groynes can be constructed to reduce the rate and retain an adequate beach along the frontage concerned. The formation and retention of an adequate, stable foreshore in front of the works is an essential part of any coast protection scheme. We have used groynes in many places around the coast and have successfully stabilised the foreshore.

Some authors have doubted the effectiveness of groynes, based upon tests carried out with models in the laboratory. This is most likely due to the difficulties arising from the scale effects, and also in attempting to reproduce the variations in wave height and direction in combination with changes in level due to tides. At the Coast Protection Conference held in Santa Barbara in 1965 it was stated that "Competence in appraisal may be the key to successful groyne installation" (ref. 1). This proves to be very true in practice. After installation long-term maintenance and adjustment to level is most essential.

A very good example of the effects of groyning a foreshore can be seen at West Wittering in Sussex (Fig.1). Prior to 1902 erosion was taking place at the rate of 5 metres per annum, but following the construction of groynes, the foreshore has been more or less stabilised.

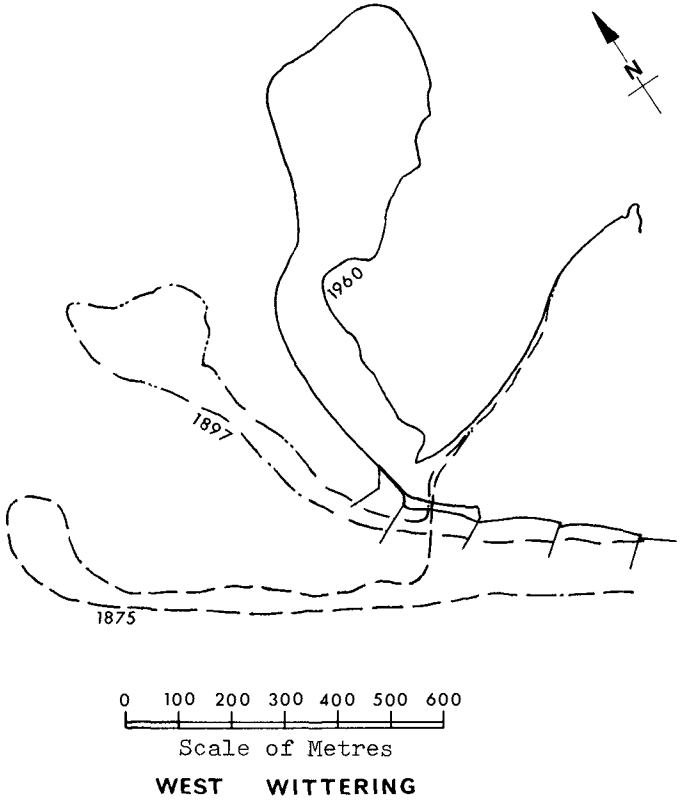


Fig.1: Movements of High Water Mark

In another case at Aberdeen on the North East coast of Scotland, the face of the sand dunes had been eroding at the rate of 2 metres per annum from 1868 up to 1962, and the foreshore was becoming steeper. Since a system of groynes was constructed in 1962, accretion has taken place between high and low water marks, and a considerable volume of sand has accumulated below low water.

There are many other examples where groynes have been used to provide an effective and economic form of coast protection and in some without the need for a sea wall.

ARTIFICIAL REPLENISHMENT

A system of groynes can only be successful where there is a sufficient supply of beach material available. In some cases where the volume of littoral drift passing along the foreshore is inadequate, it is economic to replenish artificially the foreshore from other sources.

Artificial replenishment was used on the Pett foreshore of Rye Bay on the South Coast in the nineteen thirties, and in recent years has been carried out on this and other frontages by the Kent River Authority. At Pett 30,000 cubic metres of shingle is taken annually from the natural deposits at Rye Harbour, and redistributed back along the foreshore to the west from whence it came (fig.2).

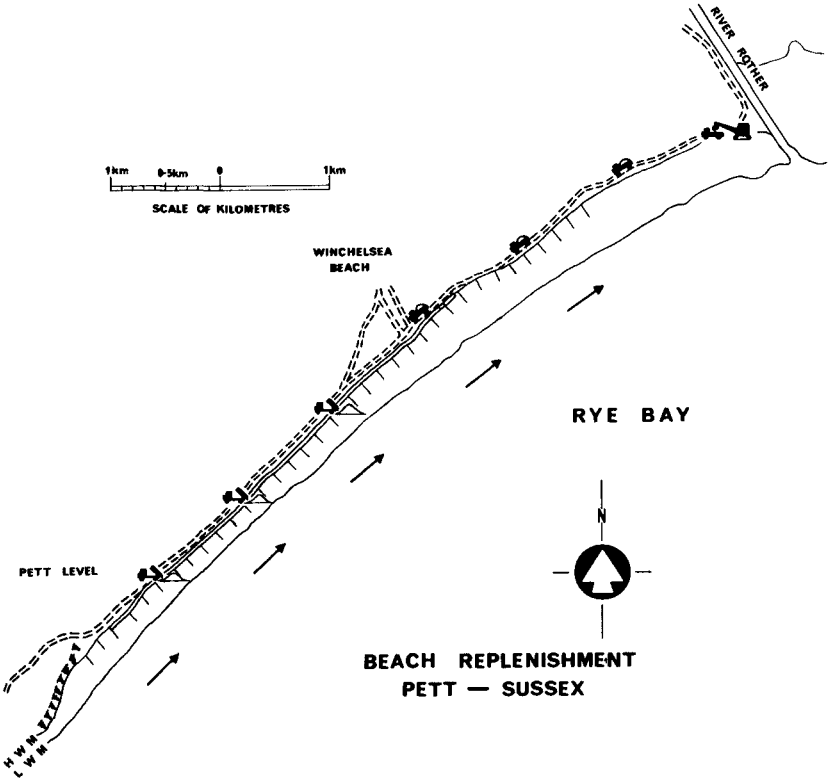


Fig. 2

A recent scheme, which includes new groynes and artificial replenishment at Clacton on the East Coast, is described in a paper presented to this Conference by W.T. Fryde (ref.2).

Replenishment can only be carried out economically where there is a nearby source of suitable material, good access to the foreshore, and where the rate of longshore drift is not high. In the future it could well become economic to replenish the foreshore in many places with material taken from offshore deposits of sand and shingle.

SEA WALLS

In many places along the coast it becomes necessary to construct a sea wall to resist further erosion, and these can be divided into two basic types:

The first of these is the vertical, mass or reinforced concrete walls, which rely on their mass to resist the violent impact caused by waves breaking against them. However, the vertical face causes considerable disturbance and the reflected waves scour the foreshore in front of the wall.

The second type is the sloping revetment, which is usually surfaced with concrete blockwork, light reinforced concrete or stone pitching, and with sheet piling to protect the toe, and a wave coping to reduce over-topping by waves. A sloping revetment enables the waves to dissipate much of their energy in running up the slope, and thus causes much less disturbance to the foreshore.

TERMINAL WORKS

Where an impermeable sea wall is introduced into a foreshore, it interferes with the natural regime, and under certain wave conditions tends to increase the erosion of the foreshore in front of the wall. To retain the natural protection which an adequate beach affords, a system of groynes can be provided to slow down the littoral drift, and retain the beach material in front of the wall. The sea wall itself in many cases, causes erosion of the unprotected coastline immediately adjoining the down drift end of the wall, while the groynes further aggravate the erosion by retaining the drift material and starving the adjoining coastline of its natural protection.

A good example of terminal erosion can be seen at Hastings, Sussex, where three miles of sea wall and groynes and a massive terminal groyne provided by the abandoned harbour arm, is causing erosion of the cliffs beyond. Over 1,000,000 cubic metres of shingle has been accumulated by the harbour arm over the last 60 years, while the rate of erosion down drift is limited by the material supplied from the 100 metre cliffs.

The terminal works should be considered indetail when the design of the main sea wall is undertaken, not added piecemeal later as the problem develops and erosion becomes serious. As with the main wall, the geophysical features of the coastline should be examined for a distance beyond both ends of the frontage being protected, especially at the end down drift from the proposed works. An adequate transitional length is essential between the section of the main sea wall and the terminal works, as an abrupt change in profile produces scour which aggravates the problem.

It is the permeability of the shingle which encourages ridges to form and build up. We can aim at producing a similar condition by providing a permeable slope which will allow the material on the foreshore to build up over the slope, but which will also retain its profile during storms. It is impracticable to give the permeable slope the freedom of movement which a natural shingle beach enjoys, so a permeable toe is provided to stabilise the bottom of the slope. The permeable slope can be constructed from many materials, but flexibility to take up movement without damage is desirable.

Gabions with suitable rock filling are highly permeable and are also flexible enough to take up settlement without damage. Where suitable fill is available locally a gabion mattress provides an effective and economic slope protection.

A steel mesh bearing onto a steel grillage, supported on light piles has also been used successfully, a layer of hardcore being placed beneath the mesh to trap the beach material.

Various types of precast concrete interlocking units have been used to protect the slope but their cost is high. These units, which can be placed in various patterns, become interlocked, and can take up settlement. The units have a high voids ratio when placed but due to their large mass, tend to create local scour which does not assist the build up of the finer beach material. At a holiday resort they can also present a danger to children who climb amongst them.

In many parts of this country wartime anti-tank blocks weighing up to six tons each are still awaiting disposal, and seem at first sight to be ideal for coast protection works of this type. Experience has shown however, that they are most unsuitable as they do not lock together, and despite their weight tend to roll in rough seas.

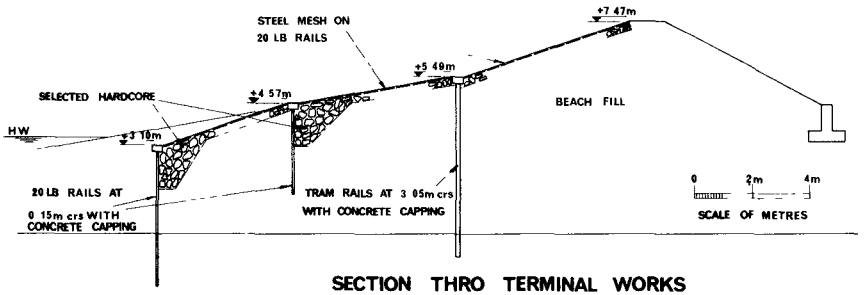
Special care is needed in determining the length and top levels of the terminal groynes, and provision should be made to allow the height of the groynes to be adjusted. Permeable groynes of timber, steel or concrete have been used, but not

extensively in the British Isles. Gabion groynes can settle to take up the beach profile but can become expensive to maintain over a long period. Timber groynes have proved most effective and economic, allowing flexibility in design and enabling the height of the planks to be readily adjusted.

EXAMPLES OF TERMINAL WORKS

Pett Level, Sussex.

This wall was constructed between 1946-50 to protect the marshes adjoining Rye Bay, and terminated in a narrow shingle ridge at the east end. The foreshore was predominantly shingle with sand towards low water, and with the littoral drift towards the east. The sea wall consisted of a sloping revetment of bitumen-jointed concrete blockwork with steel sheet toe piling, a berm, and upper blockwork with coping.



SECTION THRO TERMINAL WORKS
PETT SEA WALL SUSSEX

Fig. 3

When the terminal works were constructed all materials were in short supply, especially new mild steel sections. Old rails were used to form a permeable toe, and to support a steel grillage which was covered by war-surplus steel mesh. A layer of broken concrete was used beneath the mesh to trap

and retain the beach material (fig.3). This form of construction worked very well but in recent years has been covered by beach tipped by the Kent River Authority.

Aberdeen

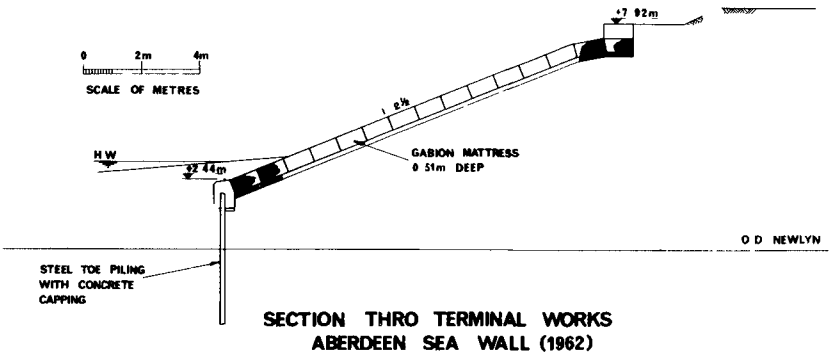


Fig. 4

This wall was constructed in 1962-63 to protect the rapidly eroding face of the sand dunes which protected the low ground behind. The foreshore was predominantly sand, and the wall terminated at the north end in the sand dunes at the River Don. With the introduction of groynes along a frontage of 2,500 metres, a terminal erosion problem was anticipated at the north end, down drift of the works. The sea wall consisted of a sloping revetment of blockwork, with steel sheet toe piling and a coping at the top of the slope.

This coast is exposed to the prevailing winds and waves from the South East, with a fetch of 600 kilometres, and waves of up to 5 metres in height have been reported. The terminal section comprises a sloping gabion mattress with steel sheet toe piling and bulkheads (fig.4). At the extreme end the toe piling is replaced by a low gabion apron.

These works allow a very satisfactory accretion of sand on the slope under most conditions, but during on-shore gales the sand is carried seaward and deposited in banks, in a similar manner to the natural foreshore to the north of the river.

References:

1. Lillevang, Omar J. "Groins and Effects - Minimizing Liabilities". Proceedings of the Santa Barbara Specialty Conference on Coastal Engineering, October 1965.

2. Fryde, W.T. "Cliff Drainage and Beach Distribution". Conference on Coastal Engineering, London, September 1968.