CHAPTER 41

CLIFF DRAINAGE AND BEACH DISTRIBUTION

by

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ABSTRACT

The works described in this paper are part of a large Coast Protection scheme recently completed at Clacton-on-Sea, Essex, England. The paper is in two parts, the first describing cliff drainage and the second dealing with beach distribution.

The method of drainage departs from the usual one of surface rubble drains and comprises a system of auger bored vertical and inclined drains. This method of drainage does not depend on the slope of the cliff face, its most important feature being that it makes it possible to drain the water away from within the cliffs.

The second section describes the effect of large impermeable groynes on beach distribution as experienced at Clacton and the remedial works carried out, including tipping of imported material to improve the beach levels, and the results achieved.

Both sections of the paper refer to the specific problems encountered on the Clacton frontage and the methods adopted to deal with them. The solutions found could be applied to other frontages but thorough investigations would be necessary beforehand due to the very varying nature between one frontage and another.

INTRODUCTION

At Clacton-on-Sea, a holiday resort on the East Coast of England, there have been coastal problems and construction works ever since the first organised attempt to stop the recession of the cliff line was undertaken in 1881. At first, only a comparatively short length of frontage was protected by a sea wall, but gradually with the urban development this was extended and today Clacton Urban District Council are

responsible for 5.9 kilometres of coastline. The cliffs, which comprise the entire length of the Clacton frontage, were always a source of problems which originated from small slips usually well above the promenade level. In 1963, however, as the result of a large slip 46 metres of promenade and sea wall were destroyed and emergency works had to be implemented. It was then that the author's firm was called in to make comprehensive recommendations, which were subsequently carried out, including among other things cliff drainage and works to improve the beach, both of which are described in this paper.

The drainage system comprises vertical and inclined auger-bored drains (Fig.1) and the beach nourishment includes a groynage system and beach tipping (Fig.3).

CLIFF DRAINAGE

Following the slip of 1963 an intensive investigation into the stability of the Clacton cliffs was carried out. First, two 15.2 m. deep boreholes were sunk from the top of the cliffs, one opposite the slip, the other some distance away, both at about 6.0 m. from the cliff edge. At each borehole core samples were taken throughout for laboratory analysis. These two boreholes established that the cliffs are of London clay, known locally as 'Platimore', capped with sand and gravel, and also that there is a ground water table about 0.6 m. above the clay and a perched water table above a thing layer of clay some 0.9 m. to 1.5 m. below ground level at the top of the cliffs. The clay was found to be fissured and containing clay stones. Laboratory tests showed among other rhings that the sand is finer at the top becoming coarser with depth and ending in a highly permeable layer of 38 mm. gravel on top of the clay.

From the geological map it was clear that the London clay extends far beyond the area concerned at Clacton and well below the foreshore level. It remained then to establish the top of the clay and for this purpose 30 boreholes at 91.4 m. centres were taken on a line more or less parallel to, and about 5.0 m. from the edge of the cliffs. The clay was found to be 3 m. to 7.6 m. below cliff top level, sloping uniformly from west to east and was capped by sand and gravel throughout. The ground water table was uniform at approximately 0.6 m. above the clay all along the line of investigation. Two further boreholes taken 61.0 m. from the cliff edge indicated that the clay top also slopes gently landwards. The level at the top of the cliffs is approximately 14.0 above Newlyn Datum throughout their length.

In addition to the boreholes the cliffs were inspected thoroughly for slips, wet spots, springs and any revetment works which had been carried out previously.

From the information available it was not difficult to arrive at the conclusion that the main cause of the cliffs' instability was water within, and therefore to stabilise the cliffs drainage was of the first importance. To substantiate this conclusion it is worth describing the special physical properties of the London Clay.

London clay (Platimore) is of the overconsolidated type of clay, which means that at one time it was subjected to a load very much greater than it is today. It is known that as a result of the great reduction in the load upon it this type of clay expands and becomes vulnerable to attack by water or atmosphere on its surface. If the clay is fissured, as it is at Clacton, the process of expansion and consequential deterioration takes place also within the fissures, which could themselves be the result of the expansion. The process is very slow, but it is continuous and progressive and this is usually the cause of sudden slips. If water is in contact with the clay the deterioration on the surface or within the fissures is very much accelerated although still comparatively slow. Because of this continuous and progressive deterioration taking place in the overconsolidated type of clay, drainage is of the utmost importance, or complete disintegration will result and the clay turns into a mud slurry. It should be stressed again that although the process of deterioration is slow it is the most important factor to be considered in a long term stabilisation of the cliffs of the overconsolidated type of clay. Scarping or laying back the cliff face alone without drainage would require a slope of not less than 1 in 6.

At Clacton the normally accepted method of laying back the cliff face to a slope of 1 in 3, and providing surface rubble drains was not possible due to the proximity of the main roadway and the urban development. The method adopted, therefore, was a combination of limited scarping of the cliff face and a system of auger-bored drains. The scarping was confined mainly to laying back the cliff face in places to a slope of 1 in 1½ and where possible 1 in 2, and general tidying up. The drainage system on the other hand is quite extensive and covers nearly 1.6 Kilometres of frontage.

Generally, the drainage system comprises vertical and inclined auger-bored drains, a toe collecting drain and sea outfalls (Fig.1). Vertical drains were constructed first in order to determine accurately at their locations the top of the clay and also to deal with the perched water table by perforating any impermeable layers within the sand and gravel. Next, from suitably located pits in the promenade, inclined holes were augered through the clay to meet the bottom of the vertical drains. The method of auger boring was specially devised by the sub-contractor using a hydraulic pack. After the auger had been withdrawn perforated pitch fibre pipes were inserted into the hole to provide a permanent drain

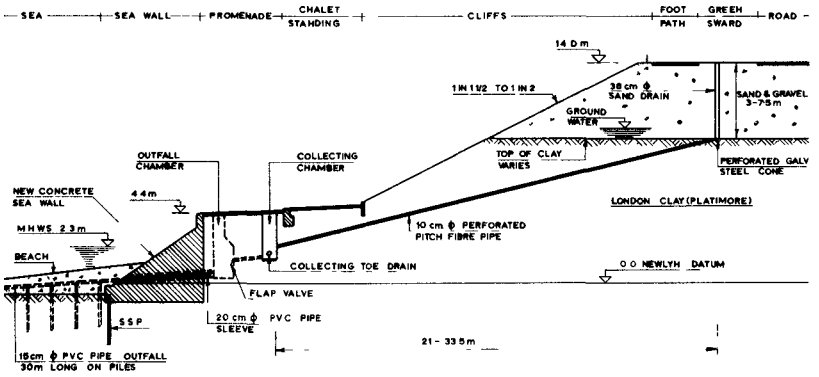

FIG 1 SECTION THROUGH THE CLIFF SHOWING THE DRAINAGE SYSTEM

within the clay and also to drain away water from the top of the clay. A perforated, galvanised metal cone was fitted to the leading pipe to prevent gravel entering the drain.

The number of vertical drains was determined from a visual survey of the condition of the cliff face, and accordingly these are at 7.6 m., 10.1 m. or 12.2 m. centres. To reduce the number of pits, which can be quite expensive, three inclined drains usually radiate from one pit towards three corresponding vertical drains. In each pit a collecting chamber is provided and this is connected with others by a collecting toe drain which discharges finally into the outfall chamber and from there the drainage water is carried by a P.V.C. pipe to the sea.

For the construction of the inclined drains a newly-developed machine called a "Traveller" was used. With this machine, using a continuous auger, up to two 24.4 m. long drains were completed per shift. Mass and reinforced concrete and brickwork can be drilled through with reasonable ease using a diamond auger bit. Non-cohesive materials on the line of the auger, however, constituted a considerable obstruction and required steel casing which can increase the cost of augering to as much as four times that of working in sound clay.

The augering as such, with or without casing, is no longer a problem, but there is still no reliable method of assessing the true line, level or position of the leading end of the drain either in the course of augering or when completed. At Clacton a "U" tube was used to determine the level of the drain at any point and the only guide as to the line was the comparison of the calculated length with the length of the completed drain.

When the auger entered the gravel strata usually a flush of water came down the augered hole bringing with it some of the material, which gave a good indication of whether the vertical drain had been met, although this is not essential since the gravel on top of the clay is quite permeable being much coarser than that higher up.

Fig.2: Auger-bored inclined drains lined with pitch fibre pipes ready for connection to the collecting toe drain.

The discharge from the drains varied. Some of the drains ran for a few days only after completion, which indicated that the extent of the water table at that location was small. Others have not ceased running indicating that a large catchment area is being drained. A number of drains did not discharge and from this it was deduced that a local high spot or ridge on top of the clay had been struck. On the whole the drainage can be considered a success since the discharge measured weekly for the past year at three of the five outfalls was almost constant at a total rate of 181,840 litres per day.

In conclusion, there is no doubt that the drainage system as described above can be used efficiently in dealing with many similar problems where normal drainage methods are neither

possible nor practical. Site investigations prior to implementation of such a scheme are of great importance and highly skilled supervision during construction is necessary.

BEACH DISTRIBUTION

The main supply of material to the Clacton beaches was cut off following the construction of a sea wall at the toe of the cliffs along the entire frontage. The supply from littoral drift is very small and therefore the only hope of preserving the beaches lies in a good system of groynes and the occasional tipping of imported material.

The previous groyne system (Fig.3) comprised large mass concrete groynes with smaller groynes of reinforced concrete or timber construction. The large groynes (Nos.34 to 43) were constructed in the years 1912 to 1927. These were 125 m. long with the top level 1.0 m. above and sloping to 2.4 m. below M.H.W.S. (2.3 m. above Newlyn Datum) from the landward to the seaward ends. These groynes were spaced at approximately 305 m. At the same time intermediate timber groynes 76 m. long at 100 m. centres were constructed. The frontage with the groynes was protected by a concrete gravity wall built at the end of the last century. In 1942-43 reinforced concrete groynes were added along the almost unprotected cliffs from groyne 34 to the eastern end of the frontage, a distance of 3.4 km. These groynes, 46 m. long and at 100 m. centres comprised reinforced concrete king piles and planks. A number of similar intermediate groynes, each 30.5 m. long, were added later along part of the distance. The cliffs remained unprotected until 1948 when works on a major sea defence scheme commenced. This scheme comprised the construction of the last two (Nos. 22 and 10) mass concrete groynes, a length of 201 m. of concrete gravity sea wall just west of groyne 22, and also a continuous reinforced concrete sheet pile wall east of groyne 10 and in the gaps between various lengths of old sea walls to the west. The mass concrete groynes were each 94.5 m. long with the top level 1.5 m. above M.H.W.S. at the landward end.

The erosion of the cliffs continued caused by the action of the waves breaking over the sheet pile wall. As a result of the damage to the cliffs that occurred during the 1953 flood an apron (promenade) behind the sheet pile sea wall was added, and with this the last gap in the cliff protection was sealed, and with it a major source of beach supply cut off. From then on gradual denudation of the beach was apparent along the greater part of the frontage and by 1963 a section of sea wall west of groyne No. 10 had collapsed and other sections were in danger. The lowering of the beach was most drastic to the leeward of the mass groynes, Nos. 10 and 22. These high groynes, completely impermeable and without any provision for adjustment, formed a barrier to the meagre littoral drift and consequently a situation similar to the

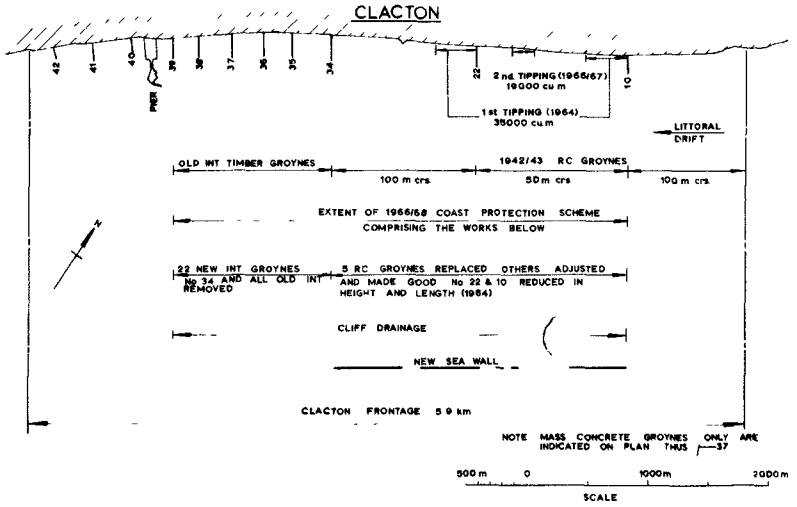

FIG 3 PLAN OF CLACTON FRONTAGE

terminal groyne problem developed (Fig. 4 and 5). This also applied to the other large groynes (nos. 34-39) near the Pier, but to a lesser degree. The problem did not arise to the west of the Pier, the conditions there being somewhat different.

To safeguard the sea wall Emergency works were carried out in 1964. These comprised shortening of groynes Nos. 22 and 10 by 30.5 m. and reducing the height by as much as 2.0 m., adjusting planks and making good as necessary the intermediate groynes. This was followed by tipping on to the beach 35,000 cubic metres of imported material.

The imported material was tipped along a distance of approximately 350 m. on the leeward side of each of the two large groynes at an average rate of 40 to 50 cubic metres per metre of frontage. At first the material was spread on the beach by a bulldozer but this was soon abandoned and the job of spreading was left to the tides with good results. Usually it took four to six tides, depending on the rate of tipping, to spread and consolidate the material over the beach sufficiently to be walked on. It is important that the beach is inspected after tipping for any soft areas, but these disappear usually after a few days but in the meantime can be a nuisance or even dangerous.

Fig. 4: Part of the frontage with large groyne No. 10 (Distance between numbered groynes 100 m.)

Fig. 5: Part of the frontage with groyne No. 22

The improvement in the beach after the completion of the Emergency Works could be seen far beyond the area of tipping and was better than had been anticipated.

The imported material matched that on the existing beach very well since it came from the cliffs that had been the main source of beach supply before the sea wall was constructed.

In 1966 a further 19,600 cubic metres of suitable material became available from cliff scarping and this was one of the works included under the Main Coast Protection Scheme along the frontage started in that year. This time there was an access problem and the material was tipped at one point only for a length of approximately 100 m. halfway between groynes Nos. 22 and 10 (Fig.3). This did not, however, affect its distribution and further improvement in beach levels were apparent almost everywhere.

Under the same scheme the groyne system was reshaped by removing old ineffective timber and some of the reinforced concrete groynes, the latter having been severely damaged by abrasion, and constructing 29 new timber groynes, each 30.5 m. long. The reinforced concrete groynes which were retained were made good and their planks adjusted to suit the beach levels. Of the large groynes only No. 34, which was already in a dilapidated condition, was replaced by a timber groyne and the others were left for the present since the cost of replacement would be considerable.

The scheme also included 1.4 kilometres of new sea wall and drainage of 3.2 km. of cliffs.

Today, four years after the first imported material was tipped there is no doubt that there is a considerable improvement in the beach levels and there is every reason to expect that the beach can be maintained in the future with occasional tipping of imported material.

For long-term action the recommendation was that a beach nourishment be implemented in conjunction with the neighbouring authorities, that is Frinton and Walton Urban District Council and the Essex River Authority. The River Authority have started investigations into possible sources of supply but nearly all the inland deposits have been purchased by commercial interests. There are extensive deposits on the sea bed but at present there appears to be no reasonable method of moving them on to the shore.