CHAPTER 81

BEACH RESTORED BY ARTIFICIAL RENOURISHMENT

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ABSTRACT

This paper describes how a once popular pleasure beach became denuded by the abstraction of sand for industry and how, in more recent times, it was restored to its former levels. The history of the area has been studied in some detail, and it can be seen that the lowering of the beach caused progressive damage to the sea wall, eventually leading to flooding of some parts of the frontage.

In the 1960's a parapet was added to certain sections of the sea wall, and local flooding was alleviated, but the lower parts of the wall and apron suffered continuously from wave attack and the situation deteriorated to an extent where complete reconstruction of the sea defences had to be considered. It was shown that a scheme involving beach renourishment by the pumping of sand from offshore provided a more economical solution and the area now enjoys the amenities provided by the restored beach.

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History of the Area.

Portobello beach lies on the South Bank of the Firth of Forth, about five kilometres from the City Centre. (Fig 1)

An early plan, dated 1783, shows that much of the foreshore, about one mile in length, was privately owned and in some cases divided by fences erected by individual owners. A description of the beach in 1798(1) states that it consisted of golden sands and dunes, and that it was free of stone or boulders - it was, in fact, the selected bathing area of the city dwellers.

Even at this time there was some industry in Portobello, and it was described as a prominent centre for the manufacture of earthenware and tiles, and quantities of building bricks. In 1799, the population of the town was stated to be 300.

In 1824, there are records of a crystal and flint glass industry and ten years later the labour force attached to those works was about 600. From 1834 onwards, the output of the glass works was devoted to the making of bottles and this continued until at least the turn of the century.

The increase in the population of the town led to many changes and in particular to the administration of the beach and foreshore. In 1860 a Promenade was constructed along part of the frontage, the maintenance thereof being derived from Public Subscription.

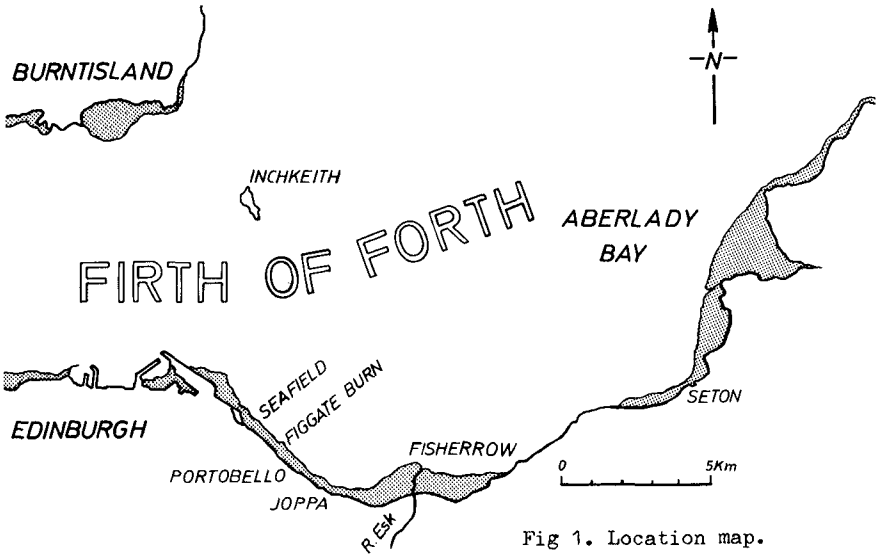

Fig 1. Location map.

In 1871, a pleasure pier was built and by this time the area had taken on the appearance of a resort, increasing in popularity year by year.

The glass industry prospered throughout these years, but the continued removal of sand for the purpose went apparently unnoticed. It is recorded that the Promenade was severely damaged by wave action during storms on a number of occasions between 1877 and 1896, but it was rebuilt and eventually extended over the entire frontage - a distance of about 1 mile.

It may be of interest to note that the bottle factory was at the western end of the frontage where more recent research has shown a net annual littoral drift of beach material from the east. It could be that the industry flourished partly on the feed of material towards it, and partly at the expense of the foreshore which was being reduced in level every year. We may never know the exact cause, but it is significant that by 1926, thirty years later, the beach level was possibly as much as two metres below the promenade level, and the wall was exposed to heavy wave attack in times of storm.

Early remedial measures.

An apron of loose rubble with a covering of cement mortar was built up along parts of the wall, but successive periods of bad weather made severe inroads on this structure. As a further precaution steel sheet piling was driven at the toe of the apron, but this too was occasionally undermined.

The glass industry no longer existed but the building trade now had an interest in the material of the beach, and it is known that the

practice of removal continued until at least the mid 1930's. Photographic records of those days show lines of horses and carts filled with sand and stones leaving the beach. It is clear from these pictures that the foreshore had by this time been reduced to stones and muddy sand. There had been a great change in 40 years.

The records show that the apron was extended to other parts of the Promenade in 1940, and that just after the war £30,000 was spent on repairs to the frontage.

Flooding.

In 1958, the City Engineer's Department consulted the Hydraulics Research Station regarding the state of the beach and the danger of flooding of some of the houses along the promenade. As a result, model tests were performed to establish the most suitable design for a parapet to be added to parts of the sea wall, and a few years later portions of the promenade were protected by this means. At the time, however, it had become clear that most of the sea wall required some maintenance and a major scheme would have to be put in hand. Either the sea wall would have to be rebuilt or some alternative scheme sought. The feasibility of a beach nourishment scheme was considered, but no adequate method could be suggested.

Reappraisal.

In 1970, the feasibility of renourishment was again considered. Amongst other considerations the study was based on the results of an offshore survey of bed material carried out in 1970 at the direction of the City Engineer.

What little sand remained on the beach at Portobello was very fine and similar to that found immediately offshore. It had a mean size of 0.20 mm. The beach slope was 1:42 and at the sea wall the sand level was between 2 and 3 m from the level of the promenade and about 1 m below the level of MHWS. The mean spring tidal range at Portobello is 5.3 m.

Any attempt to replenish the beach at this site was considered to have a better chance of success if the sand used was appreciably coarser than that already remaining. The area was exposed to considerable wind fetch from the N.E. Under wave action, coarser sand tends to move in the layers close to the bed. Here not only is the drift of water normally towards the shore, but the orbital velocities are higher towards the beach than away from it. Hence coarser material has a greater tendency to move shoreward than finer material which can be entrained in the mid-depth layers where the drift of water is away from the beach. (2)

At Fisherrow and Seton, to the east of Portobello, the beach slope was 1:12 and was made up of a coarser sand of 0.38 mm - 0.52 mm. The offshore survey showed considerable deposits of coarse sand (median size 0.27 mm) about 1 kilometre offshore of Fisherrow. Here, according to borehole samples the available volume of material would have been 600,000 cu.m. This was roughly three times the requirements of a beach renourishment operation.

The Sand Replenishment Scheme

The operation of sand replenishment started in June 1972. A 'bucket dredger' was stationed off Fisherrow at the 'borrow area'(Fig 2).

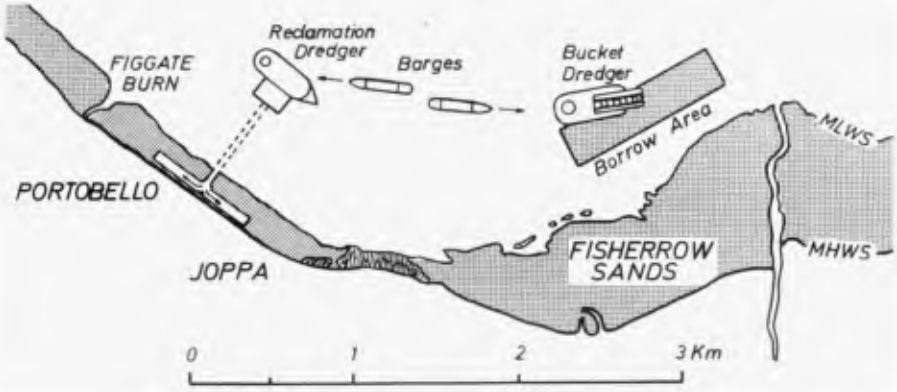

Fig 2. Renourishment scheme - general layout.

This loaded self propelled barges (each having a capacity of 500 cu.m.) which conveyed the sand at the rate of 1 load per hour to a reclamation dredger positioned some 400 m off Portobello beach (Fig 3).

Fig 3. The reclamation dredger and pipeline.

The barges were unloaded by the suction head of the dredger and the sand transferred directly ashore via a 75 cm dia. submarine pipeline.

On the beach the pipeline was bifurcated at the middle point and valves were inserted into each leg so that pumping to either side of the beach could be controlled. The weather was generally calm throughout the operation which was completed in 4 weeks.

Six groynes, equally spaced throughout the length of the beach, were constructed to hold the sand from possible movement towards the west under the action of north-easterly gales.

The beach before renourishment stood at a slope of 1:42 and was composed of a median-sized sand of 0.20 mm. The restored beach was graded to a slope of 1:20, and after 18 months was standing at a slope of 1:23. The mean size of the sand was 0.27 mm (Fig 4).

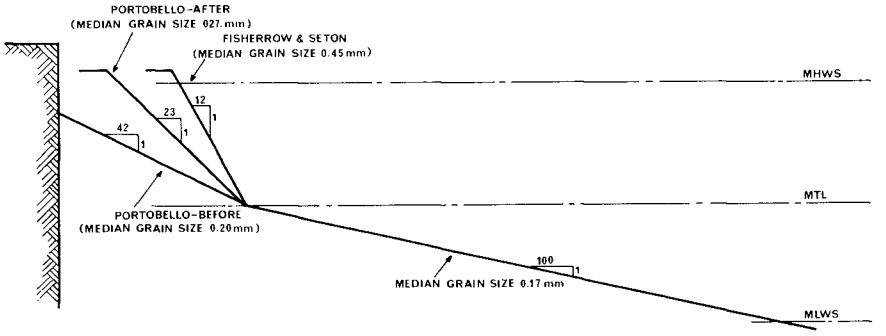

Fig 4. Beach slopes and median grain size.

Calculations on the volume of sand remaining in position show that after this period, which included nearly two winters, no loss of sand could be positively identified. The records are based on 30 cross sections throughout the total length of some $1\frac{1}{2}$ kilometres (Fig. 5).

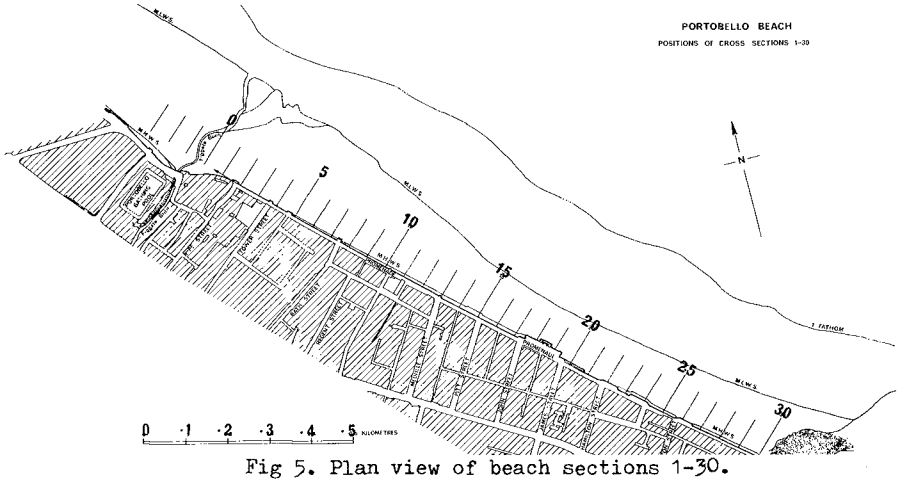

Fig 5. Plan view of beach sections 1-30.

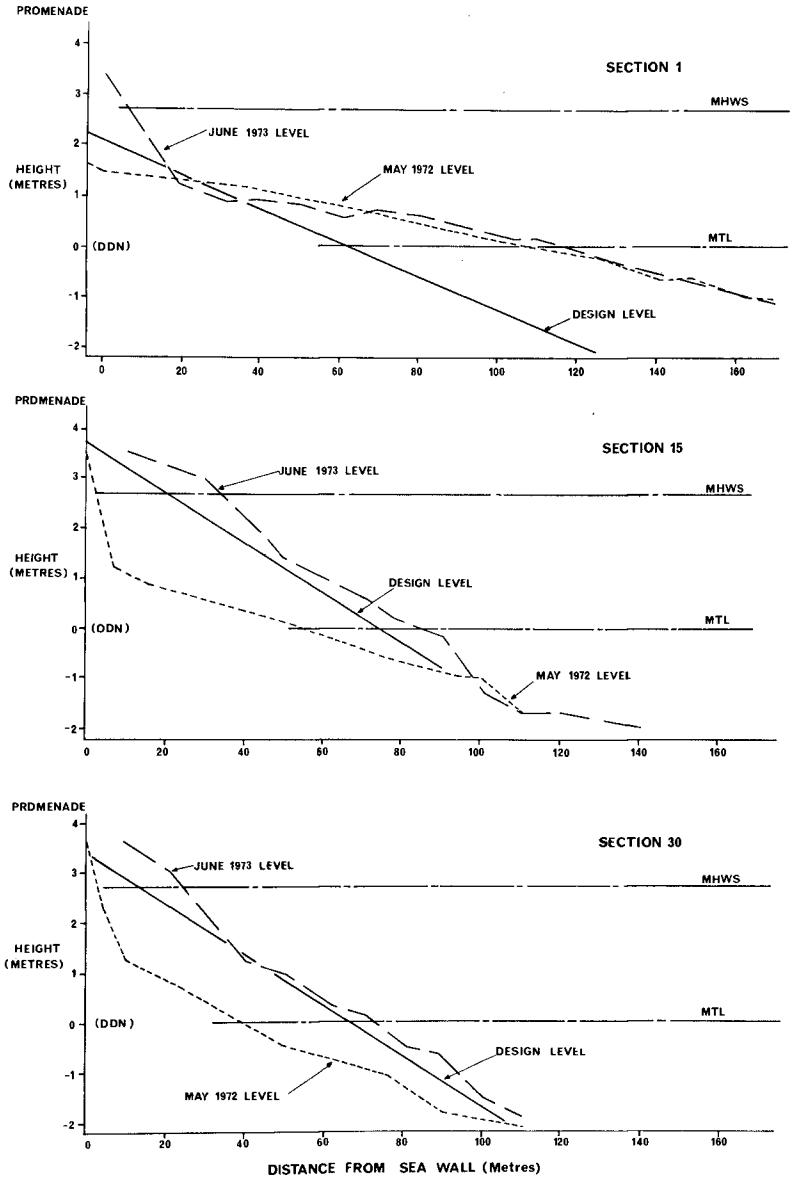

Fig 6. Comparison of three beach sections.

(a) Intermediate Section before replenishment.

(b) Intermediate Section after replenishment.

Fig. 7. Portobello Beach.

(a) Before renourishment.

(b) After renourishment.

Fig 8. Portobello Beach near western limit.

(a) Before replenishment.

(b) After replenishment.

Fig 9. Portobello beach from the air.

and whereas it is evident that some spilling of the material has occurred at the ends of the restored beach, there is little sign of any appreciable movement offshore. Fig 6 shows the centre section and the terminal sections after 2, and Fig 4 the slopes and sand sizes of the neighbouring beaches compared with Portobello.

Figs 7 and 8 show two parts of the foreshore before and after the renourishment operation. Fig 9 is an aerial picture of the beach before and after the scheme commenced.

It is understood that the City Engineer's Department would want to replace sand losses from the new beach should they be greater than 10% of the volume placed. The quantities would be assessed on a calculation based on the beach profiles.

The cost of the scheme described in this paper was £300,000 for beach replenishment, and £60,000 for the construction of five timber (greenheart) groynes and one gabion (stone) groyne. Although the estimated littoral drift at Portobello is not considered to be high, it was thought that a 'spillover' of the newly won sand towards the West might create a dredging problem at the entrance to Leith Docks.

Recent measurements taken at groyne No. 1 (Section 1 Fig 5) show that there is an accumulation of sand on the East side and a difference in level of about 1 m across the groyne. The West side of the terminal groyne will be buttressed with stone to avoid further spillage.

Acknowledgement.

This paper is contributed with the permission of the Director of the Hydraulics Research Station at Wallingford. The author is indebted to Mr. J.C.R. Smith of the office of the City Engineer, Edinburgh Corporation, for supplying details of beach profiles both before and after the operation, and also for photographic records. The assistance of Mr. V. Nash and Mr. W. Biggs in preparing hand-finished plates for inclusion in the film shown during the Conference is gratefully acknowledged.

References.

(1) BAIRD W. "The History of Duddingston and Portobello." Andrew Elliot, Edinburgh 1898.

(2) Unpublished report of work carried out at the Hydraulics Research Station, 1959.