9. EROSION OF BEACH AND INSHORE ACCORDING TO TWO-LINE SYSTEM (fig. 16). FORMULAE.

Differential equations for $t > 0$: (13) with $q_1 = 0$.

Results:

$t < 0$ (groynes not yet constructed):

$$y_{1,2} = ax^2 + \frac{2aq_2}{q_y} \cdot \frac{D_1 D_2}{D^2} \cdot \frac{D}{D_2} \cdot \frac{t}{T_o}$$

$t > 0$ (groynes constructed):

$$y_1 = ax^2 + \frac{2aq_2}{q_y} \cdot \frac{D_1 D_2}{D^2} \cdot \left(e^{-t/T_o} - 1 + \frac{t}{T_o} \right)$$

$$y_2 = ax^2 + \frac{2aq_2}{q_y} \cdot \frac{D_1 D_2}{D^2} \left\{ e^{-t/T_o} - 1 + \frac{t}{T_o} + \frac{D}{D_2} (1 - e^{-t/T_o}) \right\}$$

CHAPTER 32

THE EFFECT OF GROYNES ON STABLE BEACHES

W. A. Price, Senior Principal Scientific Officer
K. W. Tomlinson, Senior Scientific Officer
Hydraulics Research Station, Wallingford, Great Britain

ABSTRACT

The paper describes tests carried out in a wave basin to study the effect of groynes on a beach that was stable for a particular wave climate and a given supply of littoral material. The main conclusion was that on the part of the beach between H.W. and L.W. level the groynes produced no build up. The only build-up that occurred took place seaward of the impermeable groynes. Permeable groynes had little effect either inshore or offshore.

Introduction

The Hydraulics Research Station is undertaking a research programme to study the effect of groynes on beaches. The work is carried out in a wave basin 190 ft long and 75 ft wide fitted with a serpent type wave maker and equipped with tide and tidal current generators. (Plate 1).

Plate 1. Wave Basin

Description of Tests

In the absence of groynes, waves and tides were generated until the beach was in equilibrium. A check was kept on stability by surveying the beach from time to time and measuring the littoral transport in traps placed at right angles to the beach at the down drift end of the wave tank. A stable beach was normally achieved after 25 tides which amounted to approximately 31 hours continuous operation - a surprisingly long time considering the mobility of the bed material. The particular groyne installation under study was then placed on the foreshore. Again, the same waves and tides were generated and the littoral drift was measured tide by tide. During the tests with groynes the quantity of material fed to the updrift beach was the average quantity of littoral transport measured on the stable beach without groynes. This will be referred to as the "open beach drift". Surveys were carried out after 5, 10, 20, 30, 40 and 50 tides. They were used to compute the volume of coal (a) in each groyne compartment and (b) in the seaward continuation of each groyne compartment between the ends of the groynes and a level 11 in below H.W. mark. (See Fig. 1). The slope of the beach without groynes was 1:17, at mean tide level.

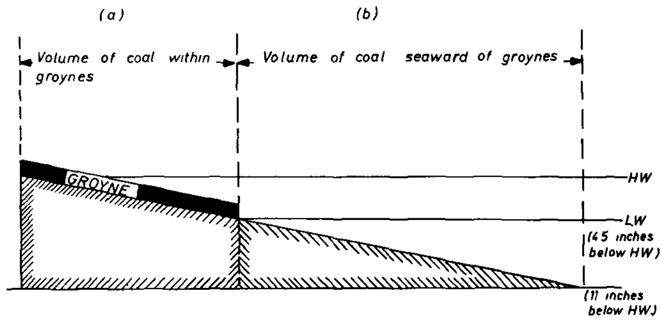

Fig. 1. Beach zones referred to in computations

In all tests the waves had a height of 2.5 in at mean tide level, a period of 1.15 secs and an angle of approach in deep water of 5 degrees. The tides had a range of 4.5 in and a period of 75 minutes. The bed material was a granulated coal which had a mean grain size of 0.8 m'm and a specific gravity of 1.35.

The following groyne installations were tested (See Fig. 2):

(i) Permeable groynes (Plate 2). These were of the Mobbs type used extensively in Norfolk - they were modelled from $\frac{1}{8}$ in diameter rod at $\frac{1}{4}$ in centres. Arranged zig-zag in plan, and at right angles to the beach, their length and spacing = 6 ft 6 in - the horizontal distance from H.W. to L.W. on the stable model beach without groynes. This dimension will be referred to as L.

(ii) Impermeable groynes (Plate 3). 1 in high and of length L they were placed at right angles to the beach and tested at 3 spacings L, $1\frac{1}{2}$L and 2L.

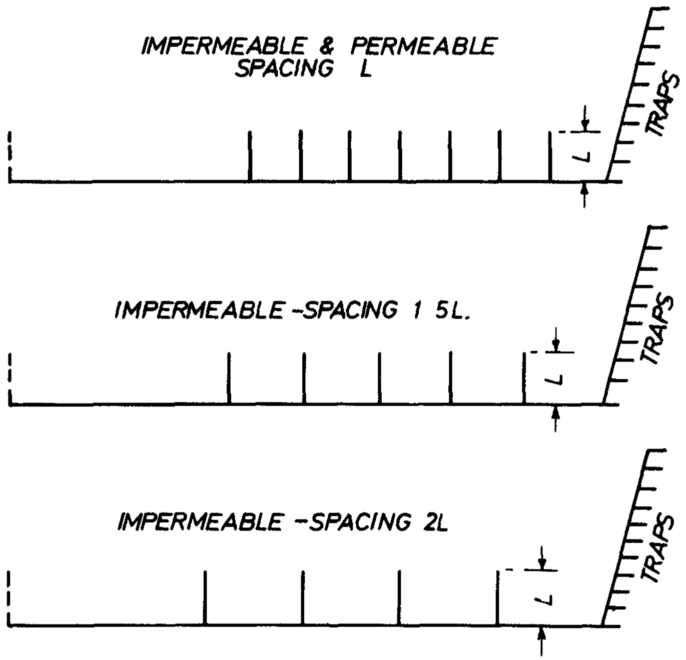

Fig. 2. Groyne installations tested

Plate 2. Permeable Groynes

Plate 3. Impermeable Groynes

Summary and Interpretation of Results

On the part of the beach within the groynes and between H.W. and L.W. marks none of the groynes produced a significant increase in beach levels. The only build-up that occurred took place seaward of the impermeable groynes. This increase not only took place in front of the groynes, but was also apparent, and even more marked in some cases, along the stretch without groynes. (See Fig. 3).

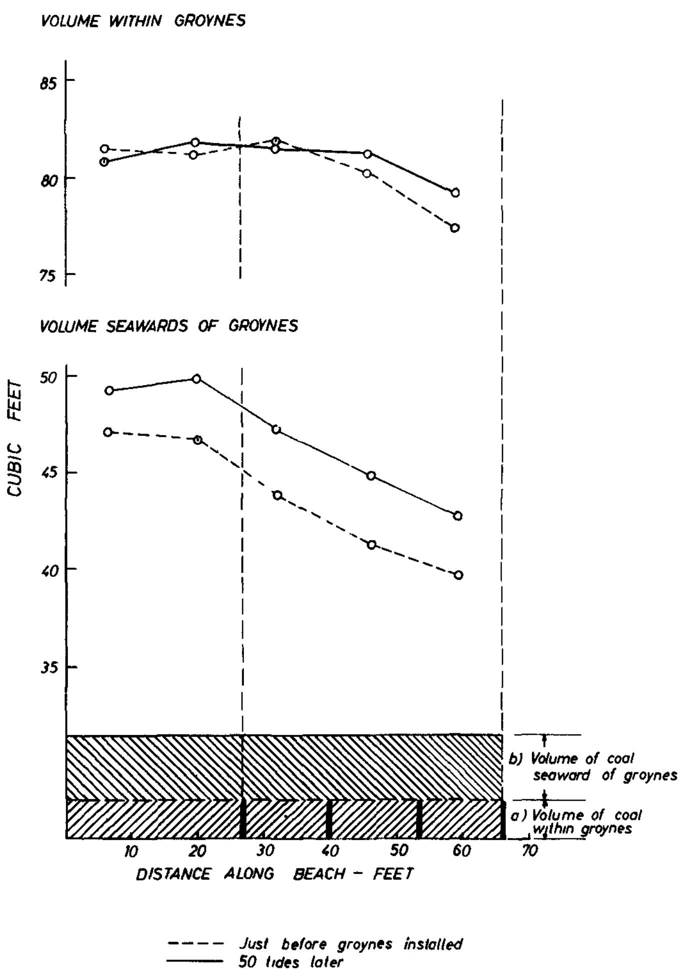

Fig. 3. Volume changes after installation of groynes.

The permeable groynes had little effect either inshore or offshore. The total drift varied considerably during the experiments. Fig. 4 demonstrates the variation that took place after the installation of groynes. Permeable and impermeable groynes at the smallest spacing L affected the total drift the least. However, up to 20 tides after installation the drift increased, indicating that erosion was taking place during this period. Subsequently the total drift dropped below the "open beach" value.

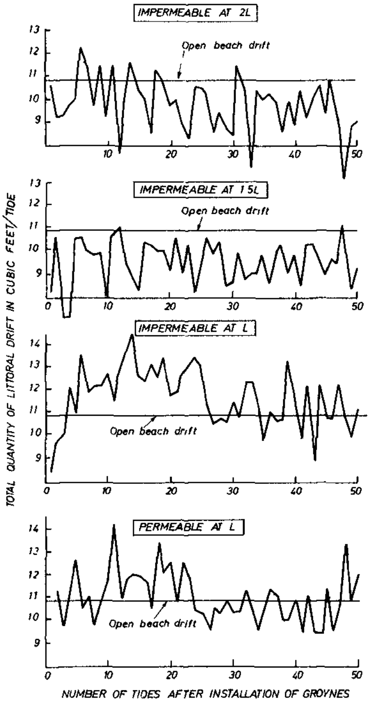

Fig. 4. Changes in littoral drift.

Impermeable groynes at a spacing of 1½L and 2L considerably reduced the total drift; the "open beach" drift was never re-established even after continuing the run for 50 tides. The area seawards of the groynes was still building up at the end of these runs.

In Fig. 3 the graph shows a reduction in the volume and cross sectional area with distance along the beach, the effect is particularly marked seaward of the groynes. This would have the effect of changing the angle of wave approach to the beach and therefore the rate of littoral drift with distance along the beach.

The intensity of littoral drift was measured at various points on the beach without groynes is shown on Fig. 5. The major part of the drift took place between mean water level and just seawards of low water. This distribution is very similar to the one put forward for sandy beaches by Knaps in 1952 (Ref. 1). In the vicinity of a groyne intensity of drift has increased in the area seawards of the end of the groyne although the total drift has been reduced.

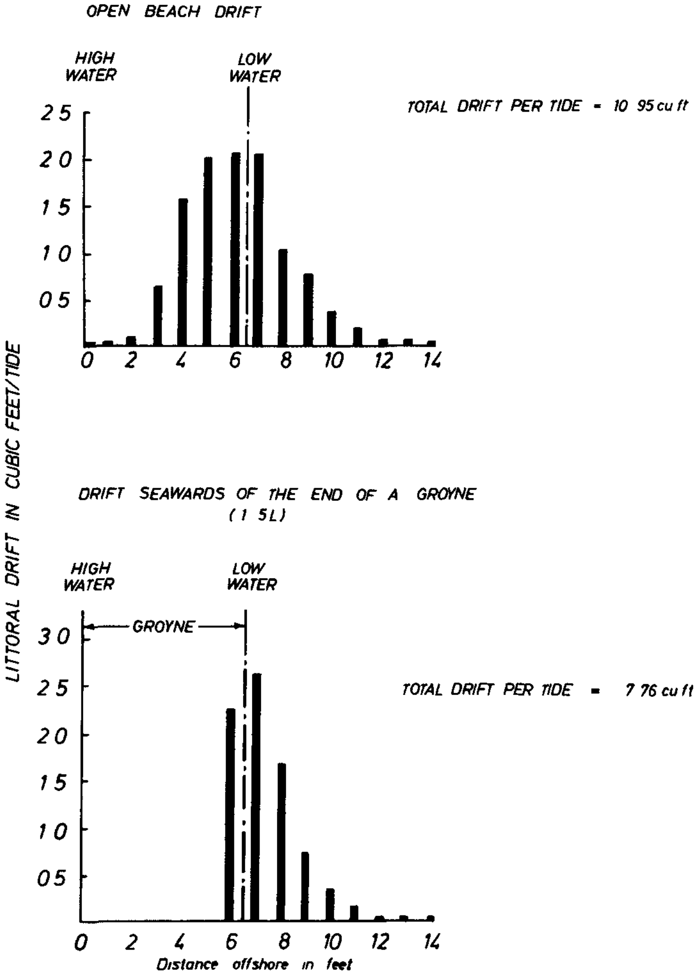

Fig. 5. Drift with and without groynes

In interpreting the results of these tests two comments are relevant. Firstly, they show the effects of groynes on a stable beach - a situation not normally met with in practice. Coastal engineers mainly use groynes on beaches that for one reason or another are eroding, though they may once have been satisfactory; a satisfactory beach, in this context, meaning one that is stable and in equilibrium with the prevailing wave climate and littoral drift. The main cause of erosion is usually that the beach has been starved of its supply of material and the groynes are used in an attempt to catch what drift there is. This is not the case under discussion; the updrift beach in the present series of tests was fed with the "open beach" drift.

A further series of tests were carried out with a deep water angle of wave approach equal to 20°, and a groyne spacing of $1\frac{1}{2}$L. The effect of the groynes on the beach was similar to that with waves from 5°, i.e. no build-up of the beach between groyne compartments was observed but the offshore sea bed levels increased significantly. The total rate of littoral drift decreased, which corresponded with the accretion on the offshore sea bed.

It might be concluded from the results of the present series of tests that when a beach is in equilibrium with the wave climate and the littoral drift, groynes are unlikely to increase beach levels. There is of course the possibility that groynes are more successful in building up or at least preventing further erosion of eroding beaches.

The build-up in the area seaward of the groynes is perhaps the most significant fact that has emerged from the present series of tests. If some time after the installation of groynes a stable topography is ever achieved the same littoral drift must pass every section as it did previously. Assuming then that the groynes inhibit the drift along the upper beach, the drift along the lower beach must be correspondingly increased. The shallower depths offshore permit the increased littoral drift along these contours.

Future research will be directed to establishing the best type of groyne installation to improve an eroding beach. There is the possibility that in this context groynes will increase foreshore levels.

References

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EXPERIMENTAL STUDY OF THE HYDRAULIC BEHAVIOUR OF GROYNE SYSTEMS

Júlio Patriarca Barceló
Research Officer. Department of Hydraulics
Laboratório Nacional de Engenharia Civil. Lisboa. Portugal

SYNOPSIS

Results of an experimental study of the hydraulic behaviour of groyne systems, a very widespread coast erosion protection structure, are described. The characteristics of the evolution of beach stretches between groynes under the action of waves with different obliquity, heights and periods are defined. The results obtained are intended for design of systems of functional groynes which secure an adequate partition of the beach in satisfactory hydraulic conditions, and also meeting use requirements, notably from the architectural and recreation standpoints. Additionally the author briefly discusses longshore drift and presents some experimental conclusions on the relations between longshore drift and the characteristics of the waves.

1 - INTRODUCTION

Coast erosion and the creation of artificial beaches are two of the main problems which arise concerning the development of coastal areas. Both the problems can, in many instances, be solved using groyne systems, (see fig.1). This type of protection is also currently used to solve accretion problems in certain coastal zones or control shoal progression. Generally, hidraulic and architectural standpoints make the design of this type of works difficult, especially the determination of the length, spacing and crown elevation of the groynes, taking into account that the groyne structure itself is ruled by hydraulic characteristics and by its required utilization which, often, involves landscaping problems. The importance of designing efficient groyne which can be applied to a large number of extensive coastal areas (see fig.2) led to the present study, the purpose of which is to contribute towards the solution of the problems presented by such systems.

Systematical tests of fixed, high and impermeable groynes was carried out, (see figs.3 and 4). The groyne slopes had different structures and they were put perpendicularly to the shoreline, corresponding to rockfill prototypes with the purpose of studying the most usual type of groynes. The pattern beaches selected for study were those which can be classified as independent physiographical units, i.e stretches of beach located between groynes long enough to prevent the transposition of mobile material at their edge. The main purpose was the determination of the evolution characteristics