

CHAPTER 27
DESIGN AND CONSTRUCTION OF GROINS

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INTRODUCTION

Groins are frequently used for shore protection and improvement. Not infrequently the owner of shore property who has had groins built to protect or improve his property is disappointed with the results. More often than not this unhappy situation must be attributed to the fact that too much was expected by the owner.

The owner in such a case is not properly to be criticized, because a great deal remains to be learned about groins; their effects, their proper design and construction.

In the present state of the art of shore protection and improvement it is not possible to design and build groins without facing numerous uncertainties, particularly in the area of advance determination of the results which will be accomplished. This condition is faced frankly at the very beginning of this paper and should be kept in mind throughout the consideration of the subject of groin design and construction.

This paper presents a digest of what is considered by the writer to be the best current practice. No pretense is made for the development of original ideas on the subject. The writer is indebted to many engineers who have contributed accounts of their experiences to the literature, and to the members of the Beach Erosion Board and its staff, especially Dr. Martin A. Mason.

DEFINITIONS

In order to assure common understanding, it would be well to begin with the few definitions which follow:

Groin. A groin is a shore protection and improvement structure, narrow in width (measured parallel to the shoreline) which extends from a point landward of the shoreline into the water a distance (length) which may vary from less than one hundred to several hundred feet. Groins are usually built to trap littoral drift, or to retard erosion of the shore. Groins may be classified as impermeable or permeable. An impermeable groin is a solid, or nearly solid, structure. A permeable groin has openings through it.

Littoral current. A current moving generally parallel and adjacent to the shoreline.

Littoral drift. The material that moves generally parallel to the shoreline under the influence of hydrodynamic forces.

Berm. The nearly horizontal formation along the beach caused by deposit of material under the influence of waves.

PURPOSE OF A GROIN SYSTEM

The purpose of a groin system is to modify the rate of supply of material to the shore and the rate of loss of material from the shore, in order to retard erosion or to cause accretion.

The condition of the shore at any time depends on the material-energy balance. By material-energy balance is meant the relation between the shore material available and the energy, usually in the form of waves, which acts on the material.

A groin system modifies the material-energy balance. If the modification is a correct one, successful results are obtained, otherwise not.

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A shore erodes when the rate of supply of material to the shore is less than the rate of loss of material from the shore. Equilibrium results when the rate of supply equals the rate of loss. Accretion occurs when the rate of supply is greater than the rate of loss.

If, under natural conditions, a shore is eroding, it may be possible for construction of groins to reduce the rate of loss to such an extent as to reverse the erosive trend and cause accretion. Alternatively, under less favorable conditions, groins could cause a condition of equilibrium or retard the extent of erosion.

In considering the use of groins to solve a particular problem, it is first essential to decide what it is desired that the groins should accomplish. Is the owner primarily interested in retarding the rate of future erosion? Or does he wish to try to obtain a wider beach?

LIMITATIONS IN APPLICATION OF THE GROIN METHOD

Having ascertained the desired goal, we can then proceed to a determination of whether or not groins are likely to be successful in accomplishing this goal.

Groin systems are unlikely to be effective in certain shore environments. The shore may consist of gently sloping rock surfaces, more or less vertical wave cut cliffs, or may be composed of gravel, boulders, sand, mud, and shell. Some shores are covered with vegetable growth, algae, grasses, reeds, or mangroves, whereas the shores of sand, gravel, and boulders are usually clear of such growth. Groins are usually considered for use only for shores composed of sand or gravel. Use of groins in any other shore environment is so rare as to be of little general interest and consequently will not be considered in this paper.

Proceeding, then, to consider other limitations in the use of groins, in the usual case, where wave action is the most important factor in moving shore material, groins perpendicular to the shore will not be successful if the waves which are most effective in moving shore material approach the shore with their crests parallel to the shoreline. The reason for this is that immediately after construction groins must modify the wave action in order to have any effect. Subsequently the material, if any, impounded by the groins, as well as the groins themselves, also modify the wave action. With groins perpendicular to the shoreline, waves must approach the shore with their crests at an angle to the shoreline in order for the groins to have any appreciable effect on the wave action. Studies to date have not indicated that construction of groins at other angles than at right angles to the shoreline would yield better results. The principal reason for this is that waves approach the shore from different directions at different times.

Another limitation is recognized in the case where the objective is to cause a substantial amount of accretion. In such a case, groins alone, no matter how they are designed or built, will not be successful if the natural volume of littoral drift is negligible.

In order, then, to determine whether or not groins are likely to be successful in accomplishing the desired objective, we must first learn something about the shore processes active in the problem area. The required information is usually classified in current practice under three major headings:

- a. The natural source of the material composing the shore;
- b. The rates of supply of material to the shore and of loss of material from the shore;
- c. The manner of movement of material to and from the shore.

A comprehensive and complete investigation to obtain this information involves, in current practice, studies of the geomorphology of the problem area, petrographic investigations of shore materials, and studies of shoreline and off-shore depth changes, the winds and waves prevalent in the area, tidal or other water level fluctuations, and the effect of existing shore structures.

Description of methods of conducting these studies is outside the scope of this paper. Some of them need improvement and work is underway in that field. Methods of analyzing the results of these studies in order to obtain data, par-

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ticularly quantitative data, also need improvement and progress is also being made in this area.

At the present time, however, it is very difficult, utilizing currently accepted methods, to obtain the basic data required. Shore protection engineers are now, and will be for some years to come, confronted with the hazards of attempting to base determinations of groin behavior on shore process data which are incomplete, or inaccurate, or both. Considerable ingenuity is needed, therefore, in making the most of shore process data which it is possible to collect.

Analysis of the obtainable shore process data and the probable effect of groins will result in a determination that groins will either be effective in accomplishing the desired purpose or that they will not. If it seems likely that groins will be effective, it is then necessary to check whether some other method will produce equally effective results at lower cost. Depending on the desired purpose, alternative methods which may be considered are seawalls, bulkheads, revetments, offshore breakwaters, artificial nourishment.

Before recommending groins, then, we must determine that groins will not only accomplish the desired purpose but that they will cost less than any other equally effective method.

In studies leading to a tentative conclusion as to the acceptability of groins, certain assumptions have to be made as to length, spacing, profile, and construction materials. If the preliminary studies favor the use of groins, these design features are then reviewed carefully and appropriate modifications made in the final design.

For preliminary studies, assumed dimensions can approximate those most commonly found in existing groin systems. The groin profile should have an inner shore horizontal section, a connecting slope, and an outer horizontal section. The length of the groins may be assumed as that necessary to extend to the 6-ft. depth. A length spacing ratio between 1 to 1 and 1 to 3 should be assumed. The groin profile should be assumed to approximate the desired beach profile down to the low water elevation, thence horizontal to the end of the groin.

For final design, the preliminary assumptions of length, profile, and spacing should be modified by application of the considerations presented in the following paragraphs.

GROIN LENGTH AND PROFILE

In most shore problems encountered in current practice, wave action is the most important cause of movement of shore material. The shore material most frequently involved in groin studies is sand.

Individual sand grains are transported by sliding, rolling, saltation (jumping), or suspension. Once a sand grain is put into suspension, the slightest movement of the surrounding water will produce a corresponding movement of the sand particle. As long as the particle remains in contact with the bottom, currents of more than 1 foot per second will be required to move even fine sand. It is probable that fine sand can be moved by high, long waves in depths of water as great as 160 ft. However, the amounts of sand thus moved are small.

So far as now known most of the movement of sand by wave action takes place in the zone extending from the shoreline to the breaker zone.

In the usual case we are considering, a groin acts by interfering, directly or indirectly, with the movement of sand particles caused by wave action. Complete interference with movement of sand particles would require a very long groin, extending, depending on the magnitude of waves in the particular area, to depths of 18 to 160 ft. It is uneconomical to build such long groins because the effectiveness of the outer portions is not commensurate with their cost. It is also undesirable, where there is a pronounced predominance in direction of littoral drift, to build such long groins because of the danger of resultant starvation and erosion of the adjacent shore in the down drift direction.

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Best current practice recognizes the intimate relationship between groin length and profile by studying both together. For convenience it will be considered that a groin will be made up of three sections:

- I. The horizontal shore section;
- II. The intermediate sloped section;
- III. The outer horizontal section.

The following steps are involved in selecting controlling dimensions of a groin:

I. THE HORIZONTAL SHORE SECTION

(1) Elevation. (a) Case 1 - High groins desired to prevent movement of material over groin landward of low water line. Determine as equal to the level of maximum wave uprush during all except the least frequent storms. High groins are used in cases where conditions simulating small bay head beaches are desired. For example, for a narrow eroding beach fronting a high eroding bluff containing a considerable percentage of beach size material, retardation of the rate of erosion is desired. High groins could be used to hold material eroded from the high bluff on the narrow beach between groins.

(b) Case 2 - Low groins desired to permit some movement of material over groins landward of low water line. Determine by adding to the maximum high water elevation which occurs frequently, the maximum normal wave height (excluding infrequent storm wave heights).

(2) Length. The shore end of each groin should be securely fastened to a bulkhead or revetment or should be well keyed into high land to the rear in order to prevent the groin from being flanked as a result of storm action. Determine the length of the horizontal shore section measured from the bulkhead, revetment, or existing surface, as appropriate, as equal to the width (measured normal to the shoreline) of beach berm desired.

II. THE INTERMEDIATE SLOPED SECTION

The top of the sloped portion of the groin should be parallel to the slope of the beach normally attained by the sand which will be affected by the groin. The lower end of the slope should be at the elevation of mean low water or as nearly at this elevation as permitted by construction considerations.

III. THE OUTER HORIZONTAL SECTION

Whether this section is needed or not depends on the rate of littoral drift. If the drift is large the outer toe of the beach slope will be adequately maintained and the outer horizontal groin section will not be needed. If the drift is small the toe of the beach slope will have a tendency to recede with resultant loss of material from the beach unless the outer horizontal groin section is added. In this case the outer horizontal groin section should be of such length as to contain the extension of the proposed beach slope to its intersection with the existing bottom.

If the littoral drift is lean, groins alone may not impound sufficient sand to provide the desired width of berm referred to in the preceding paragraphs. In that case, artificial placement of beach material will be required to make up the deficit. The method of design of the groins will be the same as described herein, the artificial fill being utilized to create the desired beach profile.

GROIN SPACING

Groin spacing is determined by estimating the beach alignment that will result from the groins. When equilibrium is established in an impounding area, the alignment of the beach is perpendicular to the resultant of the forces acting upon it. This condition corresponds to a minimum rate of change, and consequently, the rate of loss will be a minimum.

When equilibrium is established in a groin system, the alignment of the beach between any two groins is perpendicular to the resultant of the forces acting upon it. For practical purposes this alignment can be considered to be nearly parallel to the alignment in nearby impounding areas.

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If nearby impounding structures exist, the groin spacing may be determined in the following manner:

- a. Determine the geographic alignment of the shoreline immediately adjacent to and updrift from the nearby impounding structure.
- b. Project a line parallel to this alignment from the outer end of the expected beach at the down drift groin. The intersection of this line with the shoreline locates the base of the next groin.

If there is no nearby impounding structure, the alignment of equilibrium must be estimated by analysis of wave action. This is done by preparation of wave refraction diagrams (Johnson, O'Brien, and Isaacs, 1948).

TYPES OF GROINS

The most important types of groins may be classified, according to the principal construction materials customarily used, as steel sheet piling, timber, stone, or concrete. Current practice is illustrated by type designs prepared by the Beach Erosion Board and shown in Figs. 1, 2 and 3. The designs illustrated are all of impermeable groins.

Permeable groins have been built in a number of places, particularly in the Great Lakes area. Satisfactory results are claimed to have resulted from some permeable groin installations. The record shows that some owners of shore property who have had permeable groins built are satisfied that their shores are now in better condition than they were before the groins were built. Other owners are dissatisfied with the results obtained with permeable groins.

Sufficient data are not now available to establish conclusively the cause and effect relationships in these cases. Some of the difficulties involved in establishing such cause and effect relationships are well illustrated by a case observed in the Great Lakes area. A system of permeable groins was constructed along a portion of the shore of one of the Great Lakes. For a number of years thereafter, accretion occurred along this portion of the shore. The owner was naturally pleased and willing to give the groins full credit for the benefit. However, similar accretion occurred simultaneously along another portion of the shore about a mile distant where no remedial measures had been taken. It is not known, therefore, whether or not the permeable groins caused the accretion in the first instance.

In some cases where permeable groins failed to accomplish the desired objective, it is doubtful if impermeable groins would have yielded any better results. In these cases, it was hoped to trap sand when there was no sand to trap.

The real problem which is not yet solved is whether, in cases where it is reasonable to expect groins to accomplish a desired objective, permeable groins can accomplish this objective more economically and effectively than impermeable groins.

Pending further investigation of the permeable-impermeable groin problem, it is fair to say that the best current practice favors impermeable groins. For example, the Beach Erosion Board has not recommended permeable groins as a remedial measure for any problem area thus far studied.

DETAILS OF GROIN DESIGN

The details of groin design depend on the severity of exposure to wave action, the climate of the construction site, and on the construction material selected. Experience with similar structures in the locality provides the best current criteria for detailed design.

STEEL SHEET PILING GROINS

The design and construction of steel sheet piling groins should avoid the principal difficulties which have been experienced with such groins, namely:

- a. Failure resulting from insufficient penetration of the piling;
- b. Failure resulting from corrosion and abrasion of piling.

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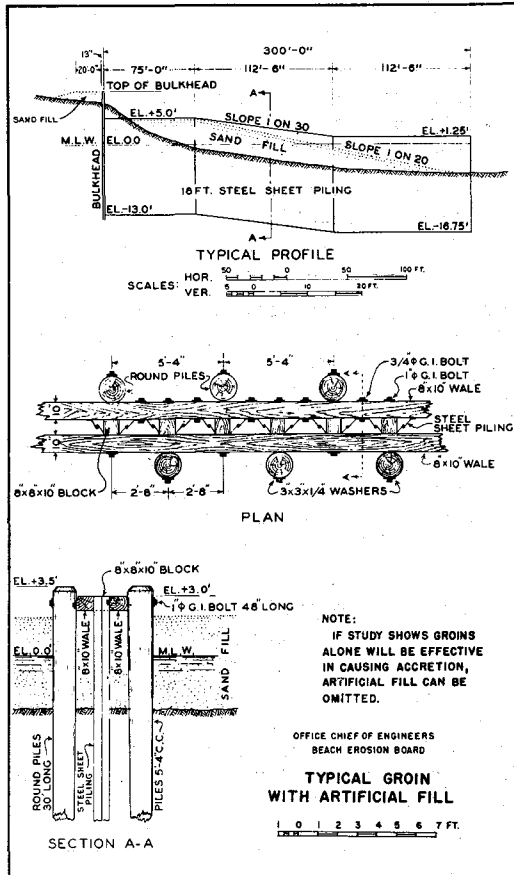


Fig. 1

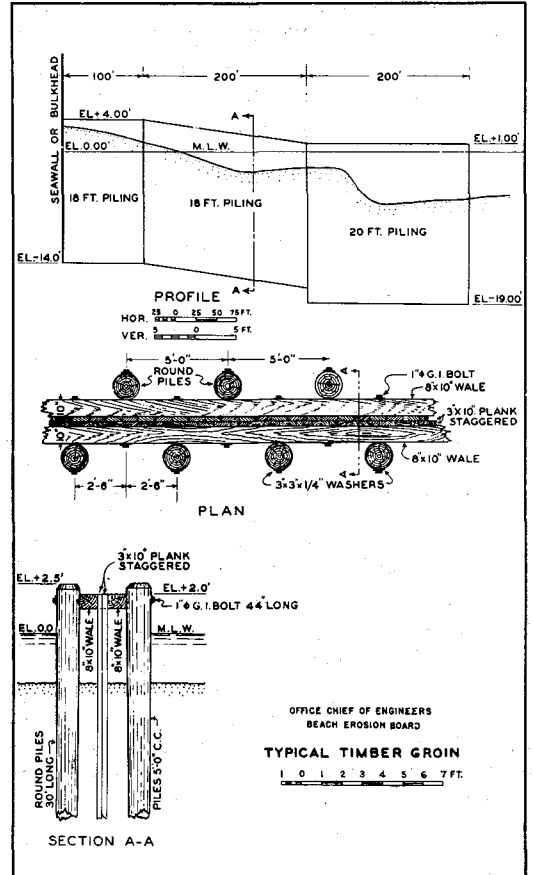


Fig. 2

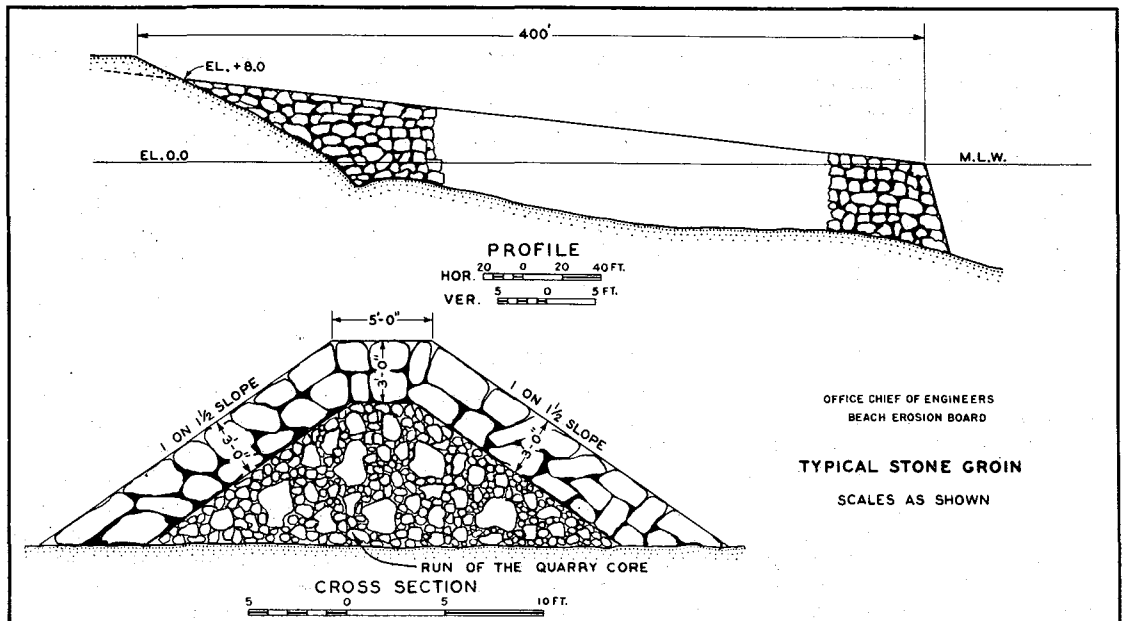


Fig. 3

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The first type of failure can be avoided by providing two-thirds penetration under the most severe erosion expected to occur.

The second type of failure can be avoided in certain areas only by costly preventive or maintenance measures. It is probably wiser to avoid the use of steel sheet piling groins in those sections of the United States where rapid deterioration of the steel piling from corrosion and sand abrasion is experienced.

Under severe conditions the useful life of steel sheet piling groins is limited to only a few years. A Beach Erosion Board publication (1948) describes the effects of severe corrosion and abrasion. The following statement is quoted from this report:

"The groins built from the arch section 0.375 inch steel piling were perforated in less than 4 years and in 7 years as much as 60 feet of a groin became useless for trapping sand. Straight section groins have somewhat longer life than do deep arch section groins of the same thickness, but holes were worn in straight section groins in less than 5 years, and in 7 years a considerable length of groin became useless as a sand barrier. Groins built from thicker sections of steel sheet piling may have proportionately longer life sufficient to more than amortize the added cost of the heavier steel when compared with groins built with thinner section piles. Holes did not appear in the groin at Palm Beach built with 0.547 inch piling until after more than 9 years."

In many localities, steel sheet piling groins have proved to be very satisfactory. In such areas, a useful life of 20 to 25 years or even more may be anticipated, if the groins are properly designed and built.

Experience with existing steel groins in the problem locality provides the best indication as to whether a reasonable length of useful life can be anticipated. In assessing experience with existing steel structures it should be noted that deterioration of steel groins results from corrosion and sand abrasion. The Palm Beach tests showed that the beach material moving under the influence of wave action was the primary factor in the rapid deterioration observed. The principal wear on the piling under similar conditions will occur in a zone a few inches above and below the sand line. Abrasion by the sand continually removes the rust covering and re-exposes the base steel to oxidation, thereby accelerating corrosion.

TIMBER GROINS

The design and construction of timber groins should avoid the major difficulties which have been experienced with groins of this type. As in the case of steel groins, provision should be made for sufficient penetration of the timber sheet piling. Another major difficulty to be avoided is deterioration of the timber resulting from marine borer attack.

Experience in the locality with existing timber structures provides the best indication of the severity of marine borer attack. At most localities in the United States where timber groins are likely to be built, the timber should be treated against marine borer attack.

STONE GROINS

Care must be taken in the design and construction of stone groins to secure the greatest practicable degree of impermeability in the core, and to use cover stone of adequate size, placed with the proper slope to withstand the wave action (and in some localities, the ice action) to which the groins will be subjected.

Experience in the locality still provides the best guidance for determination of the size of stone and the proper slope. In the absence of such experience, the formula for the calculation of rock fill dikes developed by Iribarren (1949) of Spain will be found useful. An English translation of the paper in which this formula was presented has been published by the Beach Erosion Board (Iribarren, 1949).

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CONCRETE GROINS

Concrete groins have been successfully used in some localities, notably Palm Beach, Florida, and Waikiki Beach, Territory of Hawaii, but no satisfactory formulae for their design have yet been developed.

Existing concrete groins at Waikiki Beach are exposed to such light wave action that information concerning their design would not be of general value.

A number of concrete groins 140 to 200 ft. long at Palm Beach, Florida, were reported to be in excellent condition more than 10 years after construction. These groins were built of vertical concrete posts set on 12-ft. centers with horizontal precast concrete blocks between the posts. The posts are 2-1/2- to 3-ft. by 3-1/2- to 4-1/2-ft. rectangles in cross-section with widely beveled corners. The wall blocks are 1 ft. wide and 1 ft. or more high in cross-section. The ends of the wall blocks fit into recesses in the posts. The profile of these groins is made up of a series of horizontal steps with 1-ft. risers spaced 25 feet to 50 ft. apart horizontally.

SELECTION OF GROIN TYPE

The final choice between the several types of groins which may be considered satisfactory for a given problem area is based on cost estimates. Comparative costs of the acceptable types are estimated on an annual basis. Annual costs are determined from estimates of first cost, maintenance costs, and amortization over the probable useful life of the structure.

The types of groins which are found to be acceptable are for obvious reasons different in different parts of the United States and the Territories. The most economical type of acceptable groin likewise is not universally the same. Variations in costs will from time to time require changes in selection of the groin type which will be most economical.

Because of these variable factors each case must be studied individually in the light of conditions at the time of study. The problems studied by the Beach Erosion Board are not sufficient in number or scattered systematically enough geographically to justify preparation and maintenance of current data on the most economical and acceptable types of groins regionally.

In conclusion there is one point presented in this paper which, in my opinion, deserves the strongest possible emphasis. It is of the utmost importance to make every effort to make sure before recommending groins that they will actually accomplish the desired results in a particular problem area better and more economically than any other possible method. In some problem areas groins cannot achieve the desired results. In such cases groins will fail no matter how skillfully their detailed design and construction may be carried out. It is only common sense to ascertain first the desired objective and then to select most carefully the type of remedial works that will best accomplish this objective before proceeding to detailed design. In many cases, it will be found that one of the other types of remedial works should be selected in preference to groins.

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