CHAPTER 15

LOW COST SHORE PROTECTION USED ON THE GREAT LAKES

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The purpose of this paper is to present the results of three years of field observations on low cost beach protection structures in use on the Great Lakes. The structures were studied in regard to their effectiveness as beach building and protective devices and with respect to their durability in resisting ice and wave forces. The term "low cost" refers to structures which cost between $10 and $30 per foot of frontage at 1952 prices.

INTRODUCTION

As early as 1947 the Michigan Department of Conservation became concerned over the increasing rate of beach erosion on the Michigan shore line. It was anticipated that a period of high lake levels would cause severe damage because of the extensive amount of lake front development that had taken place during the previous thirty years of relatively low levels. Many homes, resorts, public buildings, roads, and bridges had been constructed during this 30 year period without a full realization that lake levels were in the lower portion of their 5 or 6 foot range. During the period from 1950 to 1953 the lakes did rise and extensive damage has occurred.

In 1948 the University of Michigan Lake Hydraulics Laboratory was established to help in solving the problem. An extensive bibliography on beach erosion (1950a) and a booklet entitled "Beach Erosion in Michigan" (1950b) were published in 1950. The latter publication undertook to explain some of the beach erosion processes and to summarize and make readily available pertinent information from other publications. The U. S. Corps of Engineers Manual for Civil Works (1947) was extensively drawn upon. While these publications served a useful purpose, it was soon found that they did not meet the needs of the majority of the people who needed help. It was found that the Michigan shore erosion problems differed from those encountered on the sea shores not only because of a difference in the hydraulic factors but because lake shore property was predominantly in private ownership. This latter factor raised the difficult but challenging problem of finding adequate methods of protection at a minimum cost. The Lake Hydraulics Laboratory undertook a project to study this problem in cooperation with the Michigan Water Resources Commission and the Michigan Department of Conservation. The studies were started early in 1950.

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THE NATURE OF THE PROBLEM

It was apparent from the beginning of these studies that much money was being spent by property owners on structures which were inadequate structurally and that often times the methods used were ineffective or even harmful hydraulically. Sea walls were used where groins would have been more effective. Many sea walls were being built with insufficient strength to withstand the back pressure of the saturated soil or without cut-offs to prevent seepage from the shoreward side which ultimately undermined the walls. Efforts were being made to hold banks at slopes much steeper than the natural angle of repose. A typical example of completely inadequate and incorrect wall construction is shown in Figure 1. This wall has no tie backs, the sheeting is on the wrong side of the piles, the sheeting does not penetrate into the ground a sufficient distance to prevent seepage and provide strength, a double row of sheeting should be used rather than a single row and, finally, the angle of the bank is much too steep to be stable. Many walls were built without provision for preventing long shore currents from developing behind the wall as the result of overtopping by waves. The use of permeable walls and groins was widespread. Groins were often not extended far enough inshore to prevent by-passing. An example of groin and wall construction which embodies some of the errors mentioned above is shown in Figure 2. Many walls were being built parallel to shore in off-shore locations where they were ineffective and easily damaged. Revetments were frequently constructed of such coarse material that erosion continued at nearly unhampered rates between the stones.

Many homes and cottages had been built and were still being built in locations that could not be protected at a reasonable cost. Some locations were found where groups of cottages, and even entire villages, had been built on low filled land. These areas were sometimes so low, even after filling, that waves were able to beat directly against the buildings during major storms. In many areas, where high bluffs exist near the shore line, homes were built on lots so shallow that there was no room to move the buildings back as the bank receded. In some of these locations the banks have advanced and receded from time to time during the past hundred years. This caused little concern until homes or highways were built on the fluctuating portion of the land.

In order to get reasonably correct information to the public as soon as possible, preliminary results of the studies were published a year ago under the heading "Low Cost Shore Protection for the Great Lakes" (1952). An additional year of observations had been obtained at the time of the preparation of this paper. Any conclusions must still be regarded as tentative because the total period of observations is less than four years. It is expected that the observations will be continued for a number of years, or until the lake levels recede.

Fig. 1. An example of inadequate sea wall construction.

Fig. 2. An example of ineffective sea wall and groin construction.

RESEARCH PROCEDURE

The problem is being studied by making a series of observations on the protective structures of various types which have been built by individuals and groups on the shore lines of the Great Lakes. Reconnaissance surveys have been made over nearly the entire 3100 miles of Michigan shore line by engineers of the Water Resources Commission. Approximately 25 reaches of shore line, each several miles long, have been chosen for closer observation. These areas were chosen not only because they provided examples of serious erosion problems but also because the property owners in those areas have constructed interesting types of protective structures.

The observations consisted primarily of obtaining photographs of the various locations at intervals of one year or less plus additional inspections to detect any changes that might be taking place at a rapid rate. The observations are being made with two distinct objectives: one, to determine the effectiveness of different types of protective methods under varying conditions and, two, to determine the durability of structures of different types and costs under varying degrees of exposure to wave and ice action.

The great difficulty in making field studies of this type is in evaluating the effect of the many uncontrollable variables. Such factors as fetch, storm frequency, and the general nature of the beach material could be readily determined. However, in some research areas it would be desirable to determine lake bottom topography, prepare refraction diagrams and make observations on currents and littoral drift. Such an elaborate program is obviously out of the question because of the great number of locations being studied. Insofar as possible, the nature of the unknown variable factors has been estimated on the basis of observations and previous experience. It is expected that the field observations will be followed by a series of model tests in the wave tank where the effect of some of the variables can be observed under controlled conditions.

CONCLUSIONS

Although the present high water period has produced serious inroads on the shore line, more serious than any other for perhaps thirty or fifty years, there is evidence that the shores have receded even farther during the past hundred and fifty years. The natural beach and dune building processes have repaired and covered up many of these older eroded areas during low water periods. Therefore, wherever possible a practical defense against erosion damage would be to move homes, cottages, or highways back and let nature take it's course. This has been done in many locations. However, where lots are not deep enough or where rights of way are not wide enough, it is necessary to provide protective measures.

Fig. 3
Beach resulting from the use of rock filled timber crib groins.

Fig. 4.
Beach resulting from the use of concrete groins.

The protective devices in use are groins of various types, sea walls, and revetments. Protection by means of artificial sand fill, often in conjunction with a groin system, is also a standard procedure.

GROINS

It has been found that groin systems provide excellent protection in the majority of locations studied. This is because of the generous supply of sand which is available along most of the Michigan shore line. Groins temporarily hold some of the littoral drift,thus raising the beach sufficiently to break the waves before they are able to attack the steeper banks. Protection by means of groins has the great advantage, in recreational areas, of not destroying the bathing beach as is the case where sea walls are built. Typical examples of beach building by low cost groins are shown in Figures 3, 4, and 5. Figure 3 shows a series of timber crib groins on Lake Huron. In Figure 4, the entire beach outside of the cement block wall was built up after the construction of a series of concrete groins. This beach, located in the Saginaw Bay area, has been maintained in the present condition for two years. A beach in the Little Point Sable area on Lake Michigan is shown in Figure 5. Timber sheet piling groins were used in this case. Water several feet deep occurs on the lake side of the timber sea wall shown in the background of Figure 5. The observations indicate that groins should extend from 50 to 70 feet into the lake from the shore line and should extend well back into the bank at their shoreward ends. Good results have been obtained by constructing the groins so that their top edges are located one foot above highest lake levels to be expected. It has been found that groins must be of tight construction to be effective. Only in locations where wave action is mild or where the beach material is very coarse do permeable groins hold beach material. Examples of ineffective permeable groins are shown in Figure 2.

In locations where wave action is severe and where the beach material is fine, the groins must be placed approximately the same distance apart as they extend out from the shore line, thus forming squares in the water area. For less severe wave conditions or where coarse sand or gravel appears in the beach material, they may be placed much farther apart, sometimes twice as far apart as they extend outward from the shore line. In practice, the groin spacing is usually related to the locations of property boundaries. Figure 6 shows timber crib groins in an exposed portion of the Lake Huron shore where the spacing is too great. Figure 7 shows groins that are longer than necessary or desirable. Figure 8 shows groins that have not been extended into the bank a sufficient distance and are therefore in danger of being breached at their inner ends. This group of groins could well have been constructed with the same total length but with their locations shifted fifteen or twenty feet in the shoreward direction. An extensive groin system, such as is shown in Figure 8, usually requires artificial nourishment not only to supply beach material to the groin area but to keep from starving down drift locations.

Groin Construction - Three types of groin construction have been found to give good results upon the basis of the observations carried out to this time. Timber sheet piling groins are the most widely used. Groins of this type are shown in Figures 5 and 9. As previously mentioned, these are modifications of the type of construction recommended by the Corps of Engineers (1947). Credit for the original design belongs to them. They consist of two rows of white oak plank sheeting with joints overlapping, walers on both sides, and round piling spaced at approximately 8 foot intervals on one side. The piles and sheeting are installed by jetting with a stream of water from a small portable pump. It is recommended that the sheeting be driven twice as far beneath the ground as it will extend above the ground, however, many timber groins which do not quite meet these specifications have been standing for several years.

Where it is impossible to jet in timber sheeting, because of the presence of large stones or hard clay, rock filled timber crib or concrete groins are built. Timber crib groins are shown in Figures 3, 6, and 10. They are constructed by building log cribs in shallow trenches and filling with large stones after placing a layer of brush. The logs are fastened together with steel pins.

Figures 4 and 11 show concrete groins. They are built in shallow trenches and must be sufficiently massive to resist the overturning effect of the waves.

The three types of groins described and illustrated above have come to be considered the standards in low cost construction in this area. They represent the minimum standards of constructions needed to provide reasonable durability, based on observations to this time. Many other types of groin construction have been used. Usually these are cheaper variations of the types described above as, for example, timber groins with one row of sheeting rather than two. One type, illustrated in Figure 2, consisting of a stockade of cedar posts has been used so extensively in some areas that it deserves to be mentioned. This type of construction is much cheaper than the three basic types described previously. However, except perhaps under very mild conditions, it is not effective, because it is impossible to drive the posts with a tight fit. In some areas, groins of this type have been built in the form of Y's with the open V in the upper portion of the Y facing toward the lake. These have appeared to be slightly more effective than straight permeable groins

Fig. 5
Beach resulting from the use of timber sheet piling groins.

Fig. 6
Timber crib groins spaced too far apart.

Fig. 7
Examples of groins that are longer than necessary or desirable.

Fig. 8
Examples of groins which do not extend into the bank a sufficient distance.

Fig. 9
Timber sheet piling groins.

Fig. 10
Rock filled timber crib groins.

but much less effective than straight impermeable groins.

SEA WALLS

The observations have shown that sea walls accelerate erosion in front of the walls, thus partially destroying the recreational value of the area. It has also been found that sea walls present a much more difficult structural problem than do groins. Consequently, the use of walls is recommended only for those cases where there is little or no littoral drift or where valuable property is so vulnerable to wave action that it is in immediate danger of destruction.

Sea Wall Construction - The most successful type of inexpensive sea wall construction is timber sheet piling. The walls are constructed in the same manner as the groins illustrated in Figure 9, except that ties to anchor piles must be installed at least every eight feet. The sheeting should be jetted six or eight feet below the lake bottom to insure that seepage will be cut off and that piping will be prevented. Groins must be placed on the inside of the walls to prevent erosion behind the wall, due to long shore currents fed by overtopping waves. The walls must be tight to prevent the leaching out of the back fill. Whenever possible, groins should also be constructed on the lakeward side of sea walls to minimize the erosion that would otherwise occur in front of the wall.

Where very high walls are required, standard designs recommended by the Corps of Engineers (1947) are recommended. Such construction does not fall in the "low cost" category.

REVETMENTS

Revetments are less objectionable than sea walls because the turbulence in front of a revetment is much less intense than in the case of a vertical wall. Revetments are successfully used in conjunction with groin systems to protect some particularly valuable portion of a bank. It is common practice to construct stone revetments around the bases of trees.

Revetment Construction - Stone revetments have been used successfully and can be constructed at reasonable cost. Care must be taken to mix stones of various sizes to provide a filter action and thus prevent the erosive power of the waves from penetrating to the beach material under the revetment.

An interesting type of revetment built in the Saginaw Bay area is shown in Figure 12. This construction consists of concrete poured into

Fig. 11
Concrete groin.

Fig. 12
Concrete revetment.

canvas bags and placed as shown. Each bag is connected with the one below by means of a short piece of reinforcing steel. The toe of the revetment is placed in a trench several feet deep. The revetment is "four bags thick" at the toe and tapers to a thickness of one bag as it rises against the bank. Although the revetment shown in Figure 12 is two years old, it has not yet been subjected to the severe ice conditions which sometimes occur in that area.

SAND FILL

The use of sand fill to provide artificial nourishment for beaches is a standard method of shore protection. Raising the flat beach several feet is usually sufficient to cause the waves to break before attacking the vulnerable steep banks. However, if fill is placed over a limited area, it is quickly carried away by long shore currents unless it is used in conjunction with a groin system. In many cases where this method has been used, the fill was borrowed from a near shore location by means of drag lines. This practice is dangerous for bathers and is usually ineffective because the wave action tends to carry the sand back to the deep areas where it was obtained. Several locations have been observed where a supply of sand was dumped in one location on a beach as a result of a land clearing and levelling operation. In such cases the beaches for as far as 1,000 feet in the downstream direction from the clearing operation have been well supplied with sand.

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