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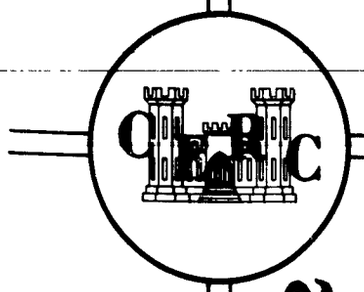

U.S. Army Coastal Engineering Research Center

CONCRETE BLOCK REVETMENT NEAR BENEDICT, MARYLAND

MISCELLANEOUS PAPER No. 1-64
January 1964

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

FOREWORD

Requests frequently addressed, formerly to the Beach Erosion Board, and currently to the Coastal Engineering Research Center, are for information as to what an individual property owner can do to protect his own relatively short shore frontage against shore erosion in the absence of a coordinated comprehensive erosion-control project for the entire problem shore. Where the problem involves eroding bluffs, banks, or backshore dunes in areas not exposed to the full fetch of the ocean, an interlocking concrete block revetment appears to offer promise as a suitable solution within economic reach of most individual property owners. The short report herein on such a revetment has therefore been published for general distribution.

If similar protective measures are to be considered for another problem area, it must be kept in mind that while the revetment structure described herein is apparently fully suitable to resist the natural forces experienced at the locality where it is built, it might not, as designed, be necessarily suitable for other areas. For instance, incident wave climate, both lunar and wind tides, and face slope of the structure dictate the individual weight of blocks to be used. Block weights now in use range from about 75 pounds, as used in the structure described herein, to weight of one ton or more as used along the ocean shore. Thus it is suggested that before proceeding with a project of this type, advice be sought from an individual well informed on the subject of coastal engineering.

The authors of this paper are engineers on the staff of the Coastal Engineering Research Center. Mr. Jay V. Hall, Jr. is Chief of the Engineering Development Division, and Mr. R. A. Jachowski is Chief of its Design Branch. The report was prepared under Coastal Engineering Research Center's continuing program to disseminate useful information to the people of the United States relative to protection of shores from erosion by waves and currents.

This paper is published under authority of Public Law 166, 79th Congress, approved 31 July 1945, as modified by Public Law 88-172, approved 7 November 1963.

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CONCRETE BLOCK REVETMENT NEAR BENEDICT, MARYLAND

by

Jay V. Hall, Jr. and R. A. Jachowski

GENERAL DESCRIPTION

The site of the concrete block revetment discussed herein is a summer camp for children on the east bank of Patuxent River in Calvert County, opposite Benedict, Maryland. It is owned and operated by Friendship House, a charitable organization of Washington, D. C. The shore area shown on Figures 1 and 2 is exposed to wind-generated waves from the westerly quadrant which occasionally reach a maximum height of 3 feet during storms. The overall wave climate of the area has been sufficiently severe to erode the river bank fronting the Friendship House property at a relatively rapid rate. The bank erosion has necessitated moving of the house on the property inland on more than one occasion.

Calvert County, Maryland lies between the Patuxent River and Chesapeake Bay and forms a part of the coastal plain. In the immediate problem area the surface is composed of the Norfolk sand which is found along the sides of all the deeper stream cuts in the southern portion of Calvert County. The Norfolk sands are the result of natural physical processes reworking the earlier sand formation of the coastal plain. The sand is generally fine and in the problem area comprises a layer about 4 feet thick. These sands lie on the Calvert formation which consists of clay, marl and diatomaceous earth. This formation is relatively wave resistant and generally remains intact, its top being at or slightly below the elevation of mean low water in the problem area, while the Norfolk sands are rapidly eroded. Figure 3 shows the wave-cut bank of the Norfolk sand fronting the property.

PROBLEM

The problem was resolved into the primary requirement of preventing the erosion of the relatively fine material forming the Norfolk sands. Numerous methods of protection are available to the engineer to stabilize this type of shore line; such as groins, bulkheads and revetments. These types of protection can be of various construction materials. In considering all types and materials, the best solution to the problem, of course, entails the selection of the structure and construction material that furnishes adequate protection at least cost.

For the area in question an attempt had been made to stabilize the shore by constructing a timber bulkhead (see Figure 3). Although the construction material used was good, the engineering design and construction were faulty in several respects. The bulkhead as constructed had insufficient penetration into firm bottom and was neither adequately braced nor tied back. Thus the structure failed by undermining and earth pressure seaward.

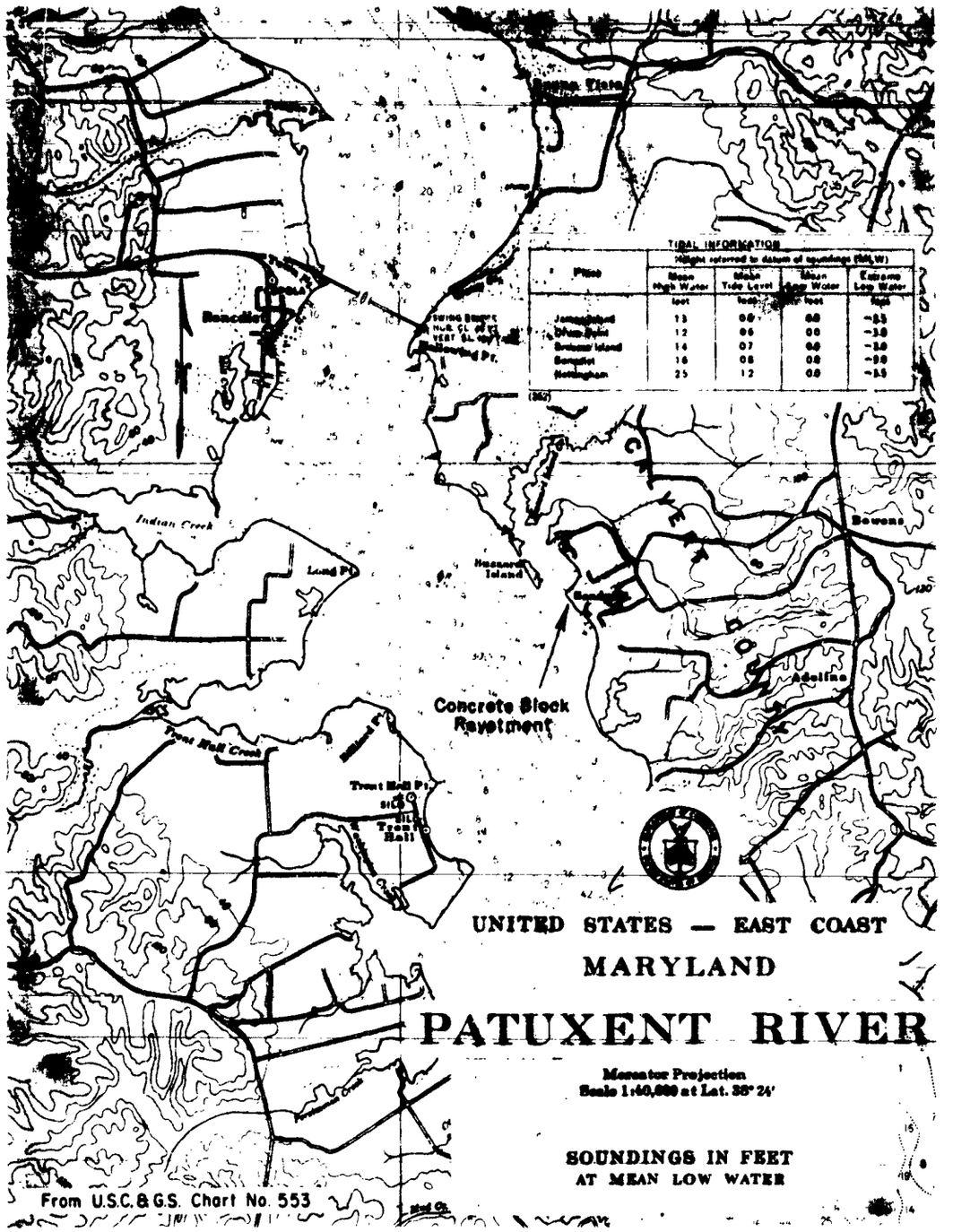


FIGURE I. LOCATION OF FRIENDSHIP HOUSE PROPERTY

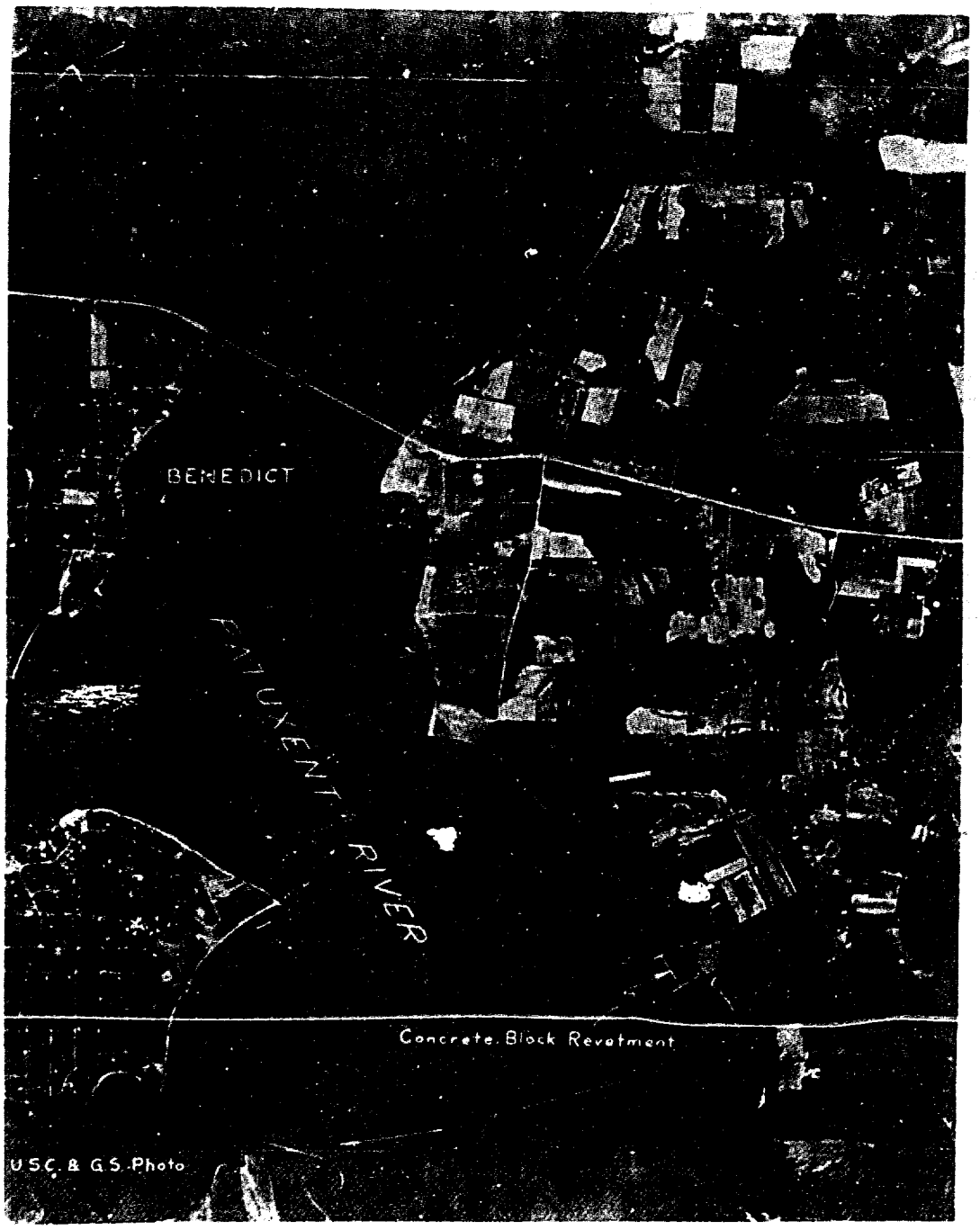


FIGURE 2 AERIAL PHOTOGRAPH OF BENEDICT AREA OF PATUXENT RIVER

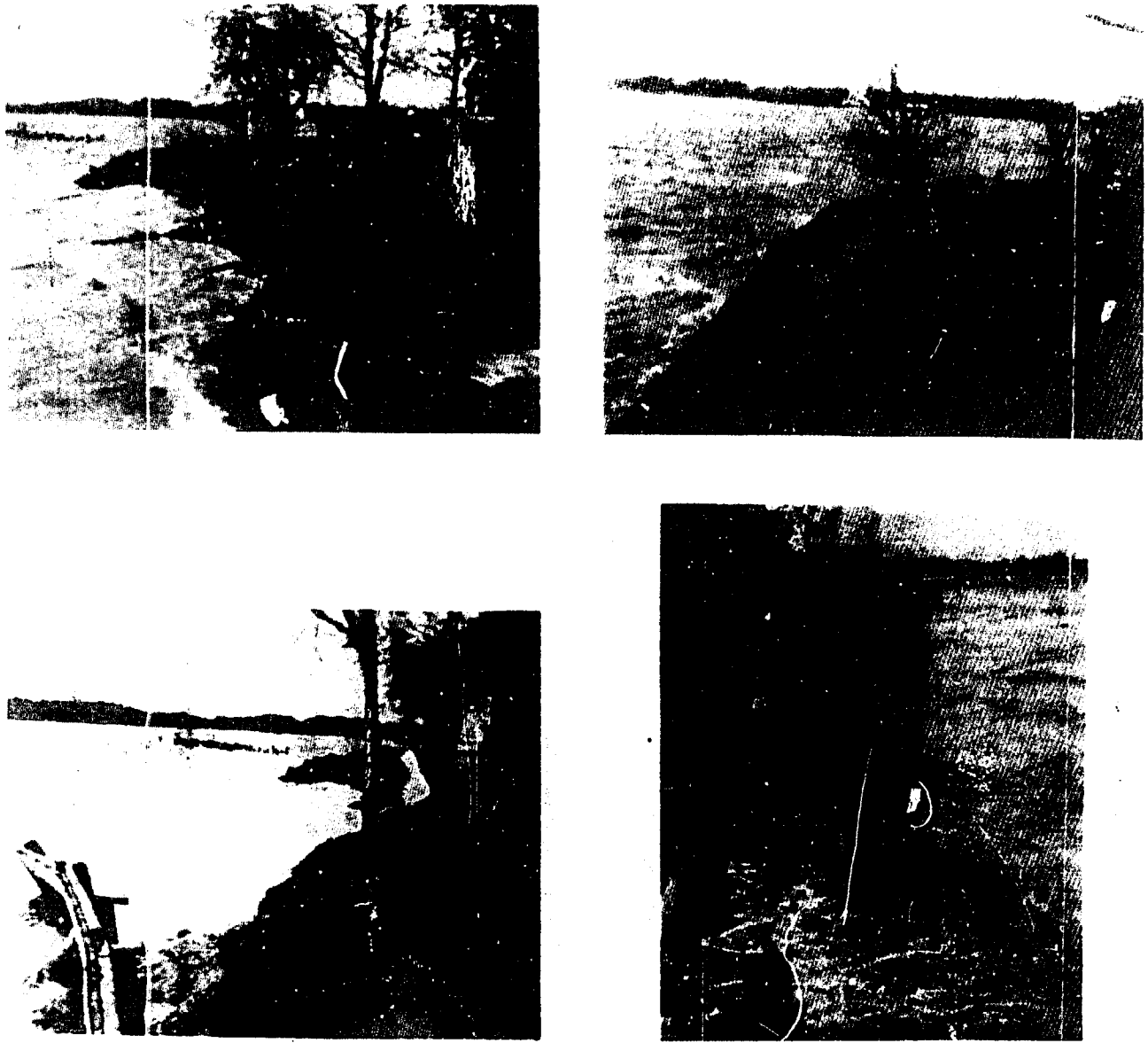


FIGURE 3. – APRIL 1962 – SITE CONDITIONS PRIOR TO CONSTRUCTION OF INTERLOCKING CONCRETE BLOCK REVETMENT

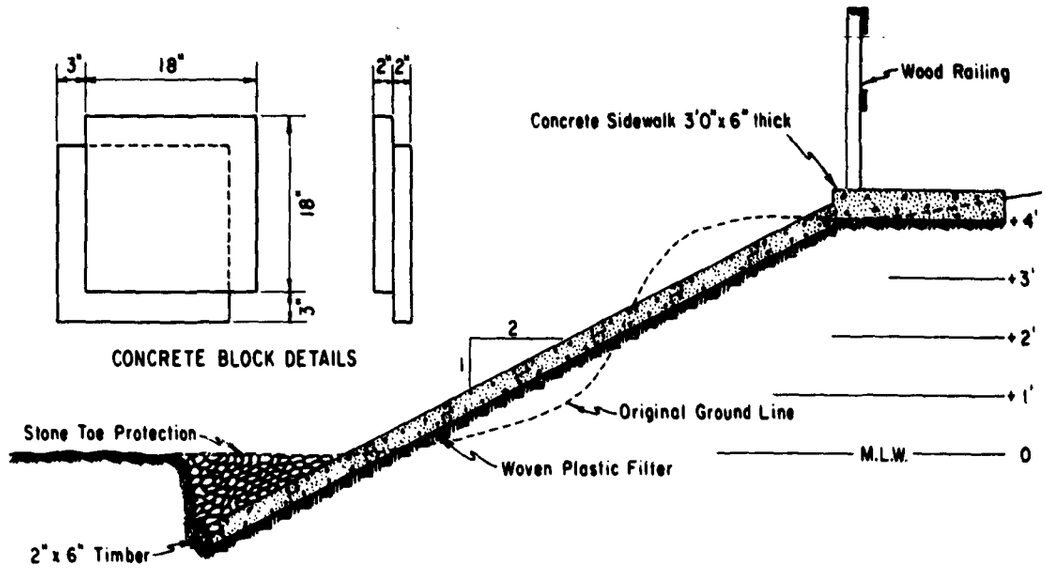


FIGURE 4. INTERLOCKING CONCRETE BLOCK REVETMENT

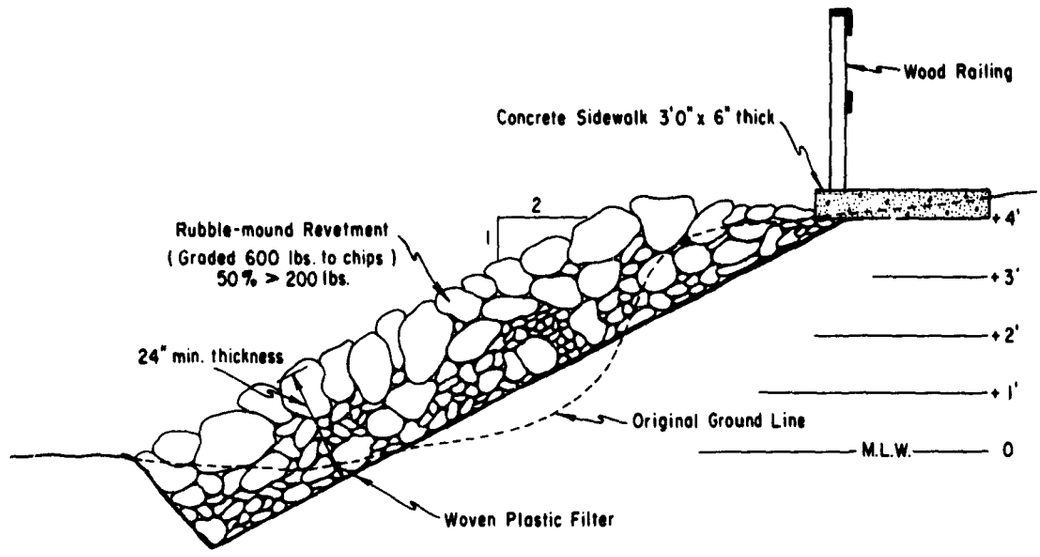


FIGURE 5. CONSIDERED RUBBLE-MOUND REVETMENT

It is altogether possible that a bulkhead could have served the purpose, if more attention had been given to the design features mentioned above. Penetration in this instance, however, was a problem, because of the firm substrata which lie at about the elevation of mean low water. A soil condition of this type is well suited to a gravity-type structure rather than a cantilever-type since the only problem to be encountered is that of preventing the erosion of the overlying sands.

SOLUTION

A number of variations of a gravity-type structure could be used to provide the protection required but the one which seemed to be most applicable to the physiography of the area near Friendship House would be some type of slope revetment.

The revetment has numerous advantages over a vertical bulkhead in that the wave energy is dissipated on the slope, thus reducing wave runup and overtopping. In the case of the vertical bulkhead, wave forces striking the vertical face are directed upward and downward causing erosion and saturation of the area behind the structure and erosion at its toe. These factors are mainly responsible for the failure of this type of structure.

Considering all factors the selection of an appropriate structure was narrowed to two types of revetment, namely a rubble structure built of quarry-run rock or one built of interlocking concrete blocks. Typical sections for structures of both of these types are shown on Figures 4 and 5. The use of either one was considered to be a satisfactory solution to the problem.

The decision as to which of the two structure types would actually be constructed then became a matter of economics. The location of the construction site at some distance from sources of natural stone made that material expensive. Investigation of costs of suitable revetment stone and concrete aggregates for casting interlocking concrete blocks resulted in estimated costs per linear foot of shore in place of $19.00 for rubble revetment and $15.00 for interlocking concrete block.

Not only does the concrete block revetment have a lesser cost but it also has other advantages. The area, as previously mentioned, is operated as a summer camp for children, and this fact makes it imperative that safety be a primary consideration. The rubble mound, unlike the interlocking block, presents an extremely rough surface on which a child could be easily injured. Further, the interlocking concrete block presents a more pleasing appearance and blends well into the rural river-front area. In view of the above cost, safety and appearance factors, the interlocking concrete block revetment was selected for installation.

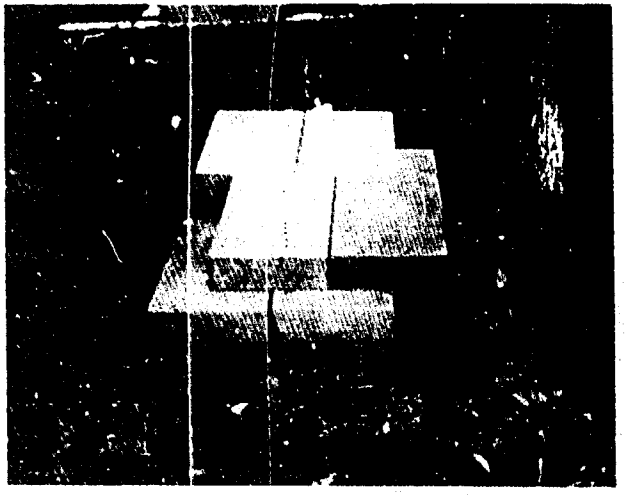
The revetment as designed and shown on Figure 4 consists of a single layer of offset concrete blocks, 21 inches on a side with an offset of

3 inches, thus presenting an 18 x 18-inch surface per block when installed. In preparation for the revetment the bank was to be graded to a 1 on 2 slope extending downward from the top of the bank to 1½ feet into the erosion-resistant lower stratum. A 2 x 6-inch creosoted timber was to be placed against the seaward face of the cut at the bottom to form a straight edge starting point for the installation of the concrete blocks. The surface of the slope was then to be covered with a woven plastic filter to prevent piping of the bed material through the joints between blocks which if permitted would result in settling of the blocks and possibly structural failure. The joints between the blocks on the slope face were to be staggered to increase the stability of the surface under wave action. In order to insure a well-anchored toe, the cut into the marl bottom was to be filled with stone. The top of the wall was to be protected by a concrete walk to prevent removal of the top row of blocks should appreciable overtopping occur.

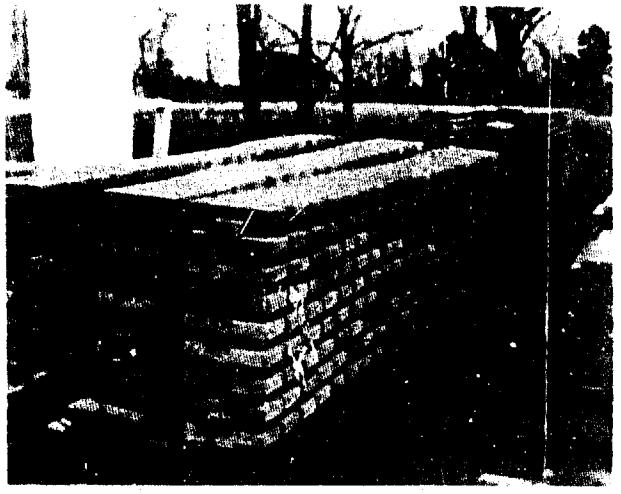
After completion of the plans but prior to advertising for bids, further efforts were made to reduce costs. Numerous concrete block manufacturers were approached regarding the possibility of their undertaking the job of producing the required units. Since only a relatively small quantity of block was involved, it was found that the high cost of providing forms for automatic block-producing machines would result in an uneconomical product; therefore, other methods of producing the block were explored. It was found that several companies in the Washington, D. C. area were equipped for automatic production of an 8" x 16" x 2" concrete patio block. Since these blocks were being manufactured in mass production, they could be purchased at a very reasonable price. However, the question remained as to whether these blocks could be suitably fabricated into the desired offset block. This led to an investigation into the use of epoxy adhesives. It was found that the fabricated blocks after being fastened together with an epoxy adhesive would be very durable if they were dry and warm when fastened. A number of tests with the cemented blocks showed the cemented joint to be as strong as the concrete in the block. In other words, the joint could not be separated without fracturing the individual patio blocks. In view of the above, the epoxy-cemented unit was accepted for use. Figure 6 shows four fabricated block units, a large quantity of fabricated units stocked for use in the revetment and a view of the fabricated block installed in the finished structure.

COSTS

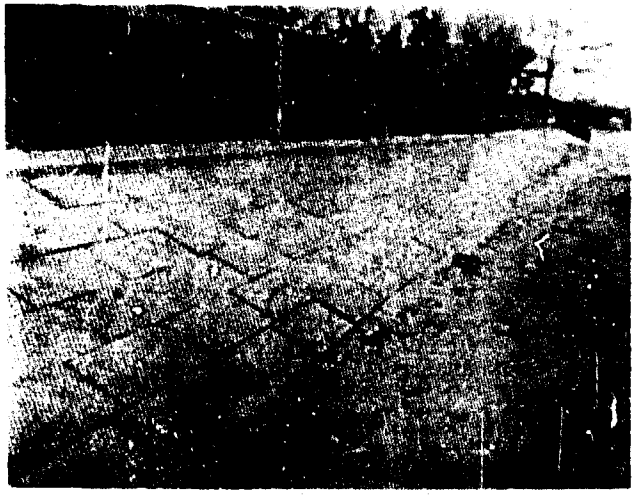
A contract for construction of the interlocking concrete block revetment was awarded through competitive bidding. The lowest bid received, which included procurement and fabrication of the blocks, removal of remnants of the old timber bulkhead, realigning the shore, grading, trenching and installation of the revetment with toe protection and walk, was about $6,000 for the 600 linear feet of shore, or a unit price of about $10.00



A - Interlocking concrete blocks fabricated from patio blocks



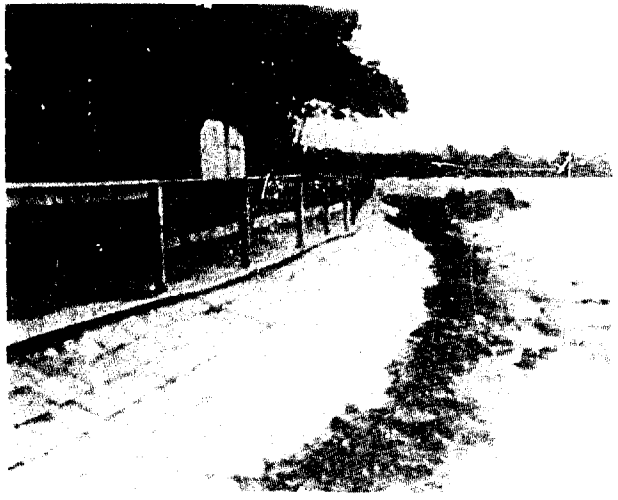
B - Stockpile of fabricated blocks



C - Fabricated blocks installed in completed structure

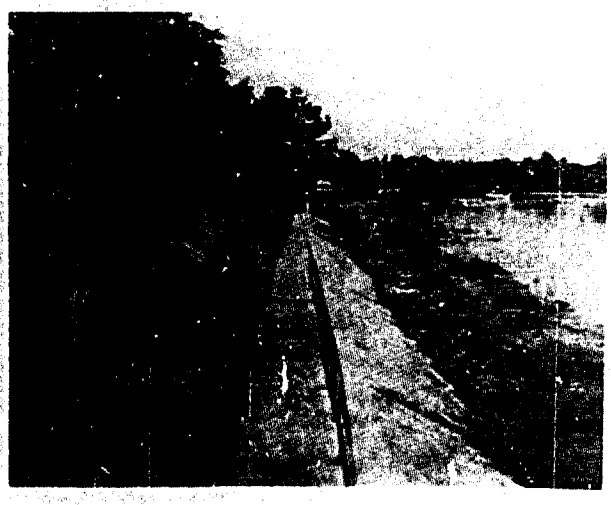
FIGURE 6 INTERLOCKING BLOCKS FABRICATED FROM CONCRETE PATIO BLOCKS

A – Looking north near northern end of revetment



B – Looking south midway along revetment

C – Looking north midway along revetment



D – Looking south near southern end of revetment

FIGURE 7 COMPLETED CONCRETE BLOCK REVETMENT – JULY 1962

per linear foot. This compares with estimated cost per linear foot of $15.00 for a hand-formed concrete block and $19.00 for a rubble revetment.

Construction was started in early May and completed in July 1962. Figure 7 shows views of the completed revetment. A railing was placed along the top of the revetment as a safety measure.

BEACH AND GROIN

Upon examining the completed project, it was noticed that there was a small quantity of littoral material moving northward along the shore. Although the construction of a beach was not included in the original project, it could be seen that the accumulation of a beach would enhance the value of the property as a summer camp. Although there were no indications of an appreciable natural source of beach material updrift, it was felt that some beach area could be provided with excess material supplied from grading operations during the construction of the revetment. With a view to stabilizing this beach area, a timber crib-type groin was designed and constructed near the downdrift extremity of the Friendship House revetment with timber salvaged from the removed timber bulkhead. After installation of the groin, sand resulting from the sorting by wave action of the excess embankment material moved into the impounding area of the groin. The operation of this structure has been very satisfactory. Within one year the groin has filled and a beach has been accumulated along the entire extent of the wall. Figure 8 shows the timber-crib groin at the downdrift end of the area and the beach accumulated along the toe of the wall by October 1963, one year after construction. The beach while serving as a bathing area also acts to dissipate wave energy and thereby reduces wave runup and overtopping on the wall.

CONCLUSIONS

Although the project has been completed for only one year, it has protected the backshore area through several winter storms. Figure 9 shows comparative photos of the area before and during construction, at completion, and one year later.

The problem of protecting banks and bluffs in the lower reaches of rivers entering Chesapeake Bay and also those of the bay, has always been difficult since many of such problem areas consist of small parcels of land with summer cottages in individual ownership. Many owners are unable to expend large sums for protection. As a result, requests for a low-cost, "do-it-yourself" method of shore protection have been numerous. The method outlined herein appears to meet these requirements. This system can no doubt be installed by an owner on a "do-it-yourself" basis at a cost even lower than the contract price for the protection at Friendship House summer camp.

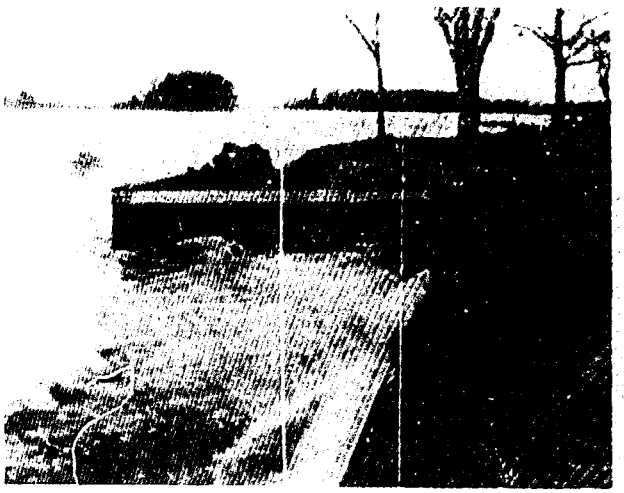
A - Looking nor h toward groin

B - Looking south (or updrift) from groin. Note downdrift end of revetment is buried

C - Looking north at southern (updrift) end of revetment

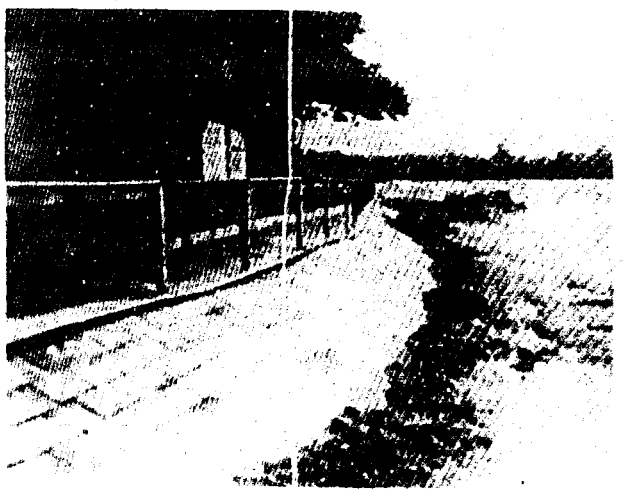
D - Locking south at southern end of revetment

FIGURE 8. SITE CONDITIONS - OCTOBER 1963



A - Pre-construction
April 1962

B - During construction
May 1962



C - Post-construction
July 1962

D - Approximately one year after completion
October 1963

FIGURE 9 COMPARATIVE VIEWS OF REVETMENT SITE CONDITIONS