CHAPTER 27

MAINTENANCE OF A NAVIGABLE CHANNEL THROUGH A BREAKTHROUGH AREA

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INTRODUCTION

The engineering problem described is one which is encountered on a portion along the Northeastern coastline where tidal currents and shifting sands are predominant features. Due to the extreme local variability of such phenomena, generalizations and similar precedents from which a solution might be adopted are seldom available. It is therefore necessary to attempt to reduce such problems to elements which can be treated by fundamental concepts. With this viewpoint, the proposed solution has been developed by applying elementary principles of energy dissipation to the local situation of a natural water passage, in which flow due to a tidal differential is essentially in one direction.

BACKGROUND AND GEOGRAPHICAL FEATURES

The area under consideration is located in the town of Chatham at the southeast "elbow" of Cape Cod, Massachusetts. Fig. 1 shows the breakthrough which separates the Monomoy Peninsula extending 10 miles south from the mainland. The eastern entrance to the breakthrough is on Pleasant Bay and is protected from the Atlantic Ocean by Nauset Beach. The westerly end of the breakthrough leads into Stage Harbor and thence via the harbor entrance into Nantucket Sound on the south shore of the Cape.

The present breakthrough dates from the hurricane of 1944, before which Monomoy Peninsula was joined to the mainland by a low, narrow beach. The area has a history of earlier breakthroughs and the entire region is noted for marked seasonal changes in sand-bar configurations, especially at the lower end of Nauset Beach. The eastern entrance of the break is approximately 1000 feet wide and tapers to 500 feet at its narrowest section. Observations over several years have shown that the entrance is becoming wider due to progressive erosion on the Monomoy side, and that the depth in the narrow section is increasing as a consequence of the increasing flow, which due to the existing tidal differential between Pleasant Bay and Stage Harbor is essentially in one direction, from east to west.

STATEMENT OF PROBLEM

The present investigation was initiated because the quantity of sand moving through the break and its subsequent deposition is rapidly threatening the usefulness of the Stage Harbor anchorage and maneuvering area. There is a definite incentive for early action with a decision to be made whether to close the break entirely or to maintain navigation through the out due to its demonstrated usefulness as a 20-mile nautical short-cut from Stage Harbor to the boating and fishing areas off the east shore of the Cape. The specific requirements of the solution may be summarized as follows:

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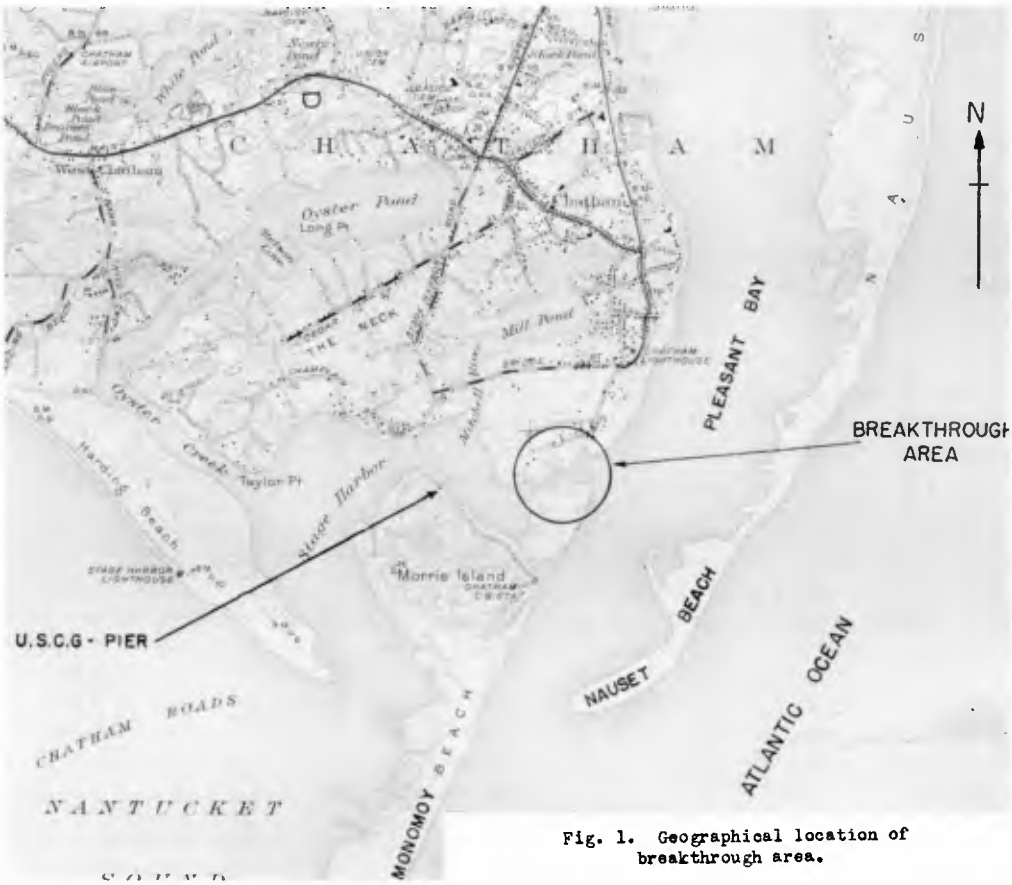

Fig. 1. Geographical location of breakthrough area.

Figure 1.

(a) The sand movement through the break is to be reduced to an amount consistent with maintaining Stage Harbor.

(b) A navigable waterway is to be provided if compatible with (a).

(c) Any proposed structures should in no way endanger present low-level buildings in the adjacent areas.

SUMMARY OF OBSERVATIONS

Simultaneous water-level observations during one tidal cycle established the fact that under mean tidal considerations, a water elevation differential of approximately four inches exists at high tide between the extreme ends of the breakthrough. The mean tide range for this area is 3.6 feet. Since the higher elevation occurs on the eastern or Atlantic side, a strong westerly current transporting large quantities of sand is produced. Fig. 2 is an aerial photograph looking west from the breakthrough entrance toward Stage Harbor showing the direction of the tidal current as determined from the orientation of sand ripples along the bottom. Velocities in excess of three knots have been observed in the narrow portion under mean tidal conditions. Fig. 3 is a similar photograph looking from Stage Harbor in an easterly direction toward the breakthrough showing the position of the

shelf of deposited sand as of February 1952. A comparison of previous surveys indicates a yearly deposition of 50,000 cubic yards of sand and a movement of the shelf into Stage Harbor at the rate of 100 feet per year. At low tide, the shelf is dry except for a narrow channel containing less than one foot of water, and under present conditions the breakthrough is navigable to small boats from about two hours before to two hours following high tide, at which time there is approximately 4 - 5 feet of water in the channel. The Coast Guard launching pier in the right center of Fig. 3 has been abandoned due to the presence of the sand shelf. Large steep-fronted sand ripples measuring 7 - 10 feet in length and 3 - 6 inches in height have been observed in this area during low tide.

PROPOSED SOLUTION

It is evident that the amount of sand transport into the harbor is related to the volume rate of flow through the break and that its reduction is dependent on decreasing this flow rate during the high-tide periods. Any solution of course must consider the economic aspects of the problem. It is therefore proposed that the discharge be reduced by minimizing both the cross-sectional area and the velocities of flow in the following manner:

Reduction of cross section can be achieved by construction of dikes from either shore leaving an opening to be determined by navigation requirements. Reduction of velocities on the other hand cannot be brought about by a simple reduction of area, inasmuch as the tidal head differential is essentially independent of the total rate of flow through the break. Velocities, therefore, can be reduced only by increasing energy dissipation such as might be obtained by greater channel roughness or by making use of turbulent dissipation at flow expansions. The latter method can be effectively achieved by constructing several dikes with navigation openings in series with subsequent energy dissipation across each flow constriction. The number of dikes is necessarily limited by economical considerations and the present proposal incorporates two such structures. Each dike would have a 30-foot navigation opening protected by wingwalls and a bottom sill of proper height to prevent under-cutting and scour at the constructed section, as well as to prevent sand movement without obstructing passage of small boats. Assuming that one-half of the total four-inch head difference occurs across each constriction, a velocity of approximately two knots may be expected locally in these openings as compared with velocities in excess of three knots under present conditions or with a single dike. It is estimated that 33 percent reduction in velocity coupled with the decrease in cross section would result in a flow of the order of 10 percent of the present rate under similar tidal conditions. It is probable that the rate of sand transport would be reduced to a greater extent than is indicated by the decrease in the flow rate. In addition, the deep pool between the two dikes would act as a sand trap for some of the material entering through the outer dike. Fig. 4 is a schematic view of the general area showing the location of the proposed dikes in relation to the breakthrough. A navigable waterway which will permit passage of small craft throughout the tidal cycle could be obtained by dredging a channel on the existing sand shelf as indicated.

Fig. 5 shows a cross section along the navigation channel extending from Stage Harbor through the break into Pleasant Bay. The function of the sills in reducing sand movement and the deep portion between the dikes are clearly illustrated.

Fig. 2. Entrance to breakthrough looking toward Stage Harbor at low tide.

Fig. 3. Position of sand shelf at Stage Harbor at end of breakthrough (Feb. 1952).

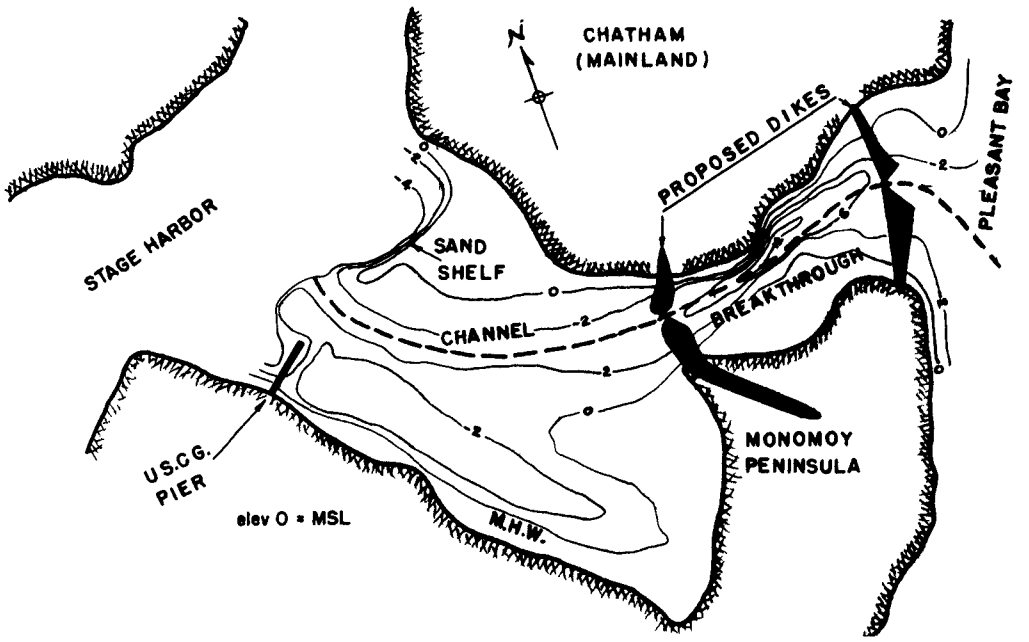

Fig. 4. Schematic view of breakthrough showing location of proposed dikes.

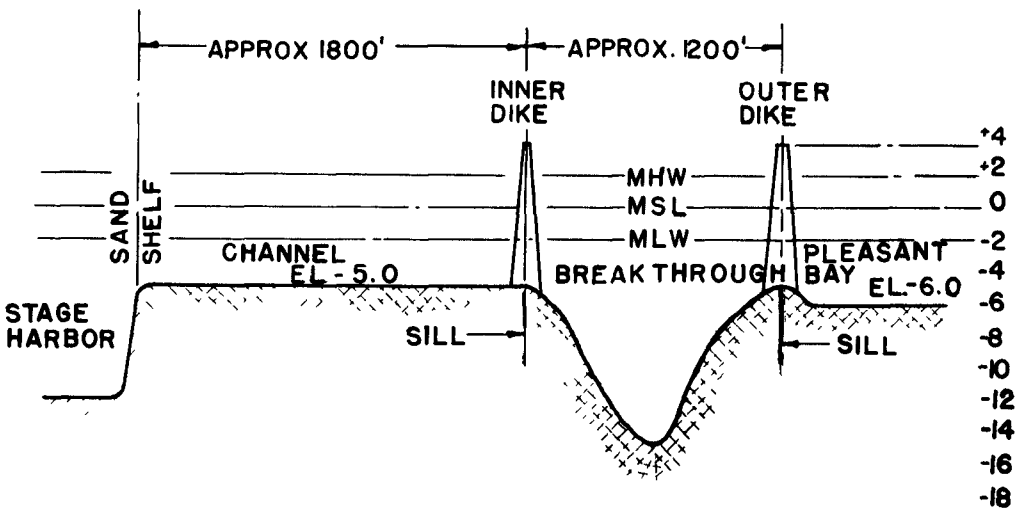

Fig. 5. Cross section along channel between outer dike and Stage Harbor.

The elevation of the top of the dikes would be two feet above mean high water, due to the presence of existing buildings at elevation 3.5 feet above M.H.W. It is therefore necessary that storm tides overtop the dikes so as not to endanger this property. Under these conditions, the outer dike would act as a weir having a crest length of over 1000 feet. The dikes are well protected against wave action from the open ocean by Nauset Beach. Observations during a severe storm showed waves breaking across this offshore beach and very little wave action in the vicinity of the breakthrough.

In a small engineering project such as this, estimated costs had to be held to an absolute minimum so therefore the dikes are proposed to be constructed as treated timber bulkheads of the type commonly used in beach groin construction. Sand obtained from dredging would be used as fill on either side of the sheet piling.