CHAPTER 18

DREDGING AT INLETS ON SANDY COASTS

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Dredging in navigation channels across off-shore bars and in tidal inlets or estuaries presents special problems not encountered in dredging in more protected inland waters. The greater exposure to wave action and often-swift and complicated reversing tidal currents impose an increased hazard of loss of or damage to dredging plant, more lost working time due to adverse conditons, increased cost of insurance, and other factors that tend to add to the difficulty and cost of such work. These special hazards require special countermeasures in the choice of a dredge, the conduct of the work, and the disposal of the dredged material. A knowledge of these factors is important to those engaged in coastal engineering.

In the United States, the choice of a dredge usually lies between the hydraulic pipe-line type, some variant of the bucket or dipper type, and the seagoing hopper type. The choice is determined by the physical characteristics of the inlet, the tidal range, the nature of the material to be removed, the exposure, the weather conditions to be expected, and other characteristics of the site.

The hydraulic pipe-line dredge consists basically of a square-end, flat-bottom, scow-type hull, in which are mounted a powerful centrifugal pump with its driving and auxiliary machinery. At one end of the hull is the "ladder," hinged at the hull end, and carrying the intake pipe and the cutter shaft. The forward end of the ladder is raised or lowered through an A-frame at the forward end of the hull. At the aft end of the hull, the discharge line from the pump emerges and is carried to the disposal area or to shore on a series of pontoons. Two vertical timber or steel spuds are also supported on a frame at that end; these can be raised or lowered independently. In operation, one spud is lowered to engage the bottom and hold the dredge in place, the ladder is lowered to the bottom, the revolving cutter stirs the material into suspension, the pump draws the water and suspended material up through the intake pipe and forces it out through the discharge line to the dumping area. The ladder end of the dredge is swung back and forth while pumping by a "swinging cable" passing around a drum in the operating machinery and extending thence laterally on each side of the dredge to a heavy swinging anchor. The dredge progresses forward by swinging alternately around first one and then the other spud. The dredge usually has no propelling machinery, and must be moved by towboat.

The bucket- or dipper-type dredge is similar to the hydraulic pipe-line except that it has no pump and no intake or discharge lines. Instead of the ladder it has a hinged boom, on which is mounted a controlled bucket or dipper of one of several different types. The material dug must be deposited either within the reach of the boom or, more commonly in open water, in scows for removal to a more remote dumping area.

The seagoing hopper dredge has a ship's hull, with propelling as well as pumping machinery. The material may be picked up, while the dredge moves slowly along the dredging range, by one suction pipe in a well amidships or by two suction pipes, one on each side of the ship. The pumps discharge into hoppers or bins amidships; the heavy material settles out in the hoppers while the water passes overboard through scuppers at the tops of the hoppers. When a load has been pumped, the pumps are cut off, the section lines are raised, and the dredge proceeds to the dump. Gates in the bottoms of the hoppers are then opened and the load slides through them into the dumping area. The gates are then closed and the operation is repeated.

The hydraulic pipe-line dredge has the following advantages:

a. It draws less water than the hopper dredge.

b. It operates continuously while at work.

c. It disposes of its material nearby -- to replenish beaches, create bases for jetties, provide shore fill to create real estate, eliminate mosquitoes, or for other useful purposes.

d. It is, under favorable conditions, the least costly to operate.

It has the following disadvantages:

a. Its low freeboard.

b. Its floating pipe line, swinging cables, ladder, and spuds are easily damaged by waves or currents.

c. Its comparative inability to remove rock unless well blasted.

d. Its relative immobility and lack of maneuverability.

The dipper-type dredge has the advantages of the hydraulic pipe-line dredge as to shallow draft and continuous operation while at work, and the additional advantage that it can remove rock with comparatively less blasting or, in soft or loose rock, with no blasting. It has the disadvantages of the hydraulic pipe-line dredge as to low freeboard, easily damaged boom and spuds, and relative immobility; it must, in addition, normally load its material into scows for movement to the dump. In soft material its output is lower than that of a comparable hydraulic pipe-line dredge, but in hard material it may be able to remove material more cheaply than could a hydraulic pipe-line dredge with complete blasting.

The seagoing hopper dredge has the sole advantage that it is self-propelled and seaworthy in any reasonable weather, and, therefore, more self-reliant. It can work in waves and currents that would compel either of the other types to withdraw, and it can reach shelter more quickly in case of sudden squalls or storms. It has the disadvantage of greater draft, so that it can only work in a minimum water depth greater than that needed by the other two types; it requires a turning basin of adequate depth and area at the inner end of its work, and it loses dredging time while en route to and from the dump. A theoretical disadvantage is that the only hopper dredges in this country are owned by the United States, but this is counteracted by the fact that the United States is about the only agency now interested in dredging inlets. In any event, if local authorities (such as a municipality, port authority, etc.) require dredging in an inlet or harbor entrance that can only be done practically by a hopper dredge, it is possible to arrange that the work be done by a United States dredge, the money to cover the cost being provided by the local agency. This was recently done in Pascagoula Harbor, Mississippi, when the Federal project harbor 25 ft. deep on the bar and 22 ft. deep across Mississippi Sound was deepened by the United States to 35 ft. on the bar and 30 ft. across Mississippi Sound at the request of local interests and with $750,000 advanced by the Port Authority and the State to cover the cost. The 35 ft. depth in the entrance bar channel was so provided with the United States 3,000-cubic-yard hopper dredge Langfitt, which removed 790,168 cubic yards of soft material at a unit cost of $0.1167 a cubic yard.

All things considered, the Corps of Engineers prefers to do the dredging in exposed offshore-bar and entrance channels with seagoing hopper dredges whenever feasible. Two principal conditions limit this practice; (1) the material to be removed must be soft and (2) there must be adequate initial depth in the channel and the inside turning area to accommodate the dredge. When these conditions exist, it is often advantageous to assign some part, at least, of the inner-harbor channel also to be dredged by the hopper dredge to keep it busy whenever the outside channel is too rough for work.

The hopper dredges now in use by the Corps of Engineers range upward from the "Lyman" class, drawing 13 ft. fully loaded with 700 cubic yards, to the "Essayons," an 8,000-cubic-yard giant drawing 27-1/2 ft. loaded. The least depth in which a hopper dredge can work at full efficiency is, therefore, about 14 ft. However, dredges of the "Lyman" class draw 11 ft.-3 in. when carrying 300 cubic yards; it is, therefore, possible with these dredges to start a cut in a depth of 12 ft. by dredging less than a half load at a time. Furthermore, if the channel to be dredged is subject to a considerable tidal range, a pilot cut can be started on a depth of about 12 ft. at high water only, increasing the load and the duration of the operation as the pilot cut is deepened until the full depth of 14 ft. or more at low water is secured, when the channel is widened to its project width on full-time operation. In view of this limitation on the use of hopper dredges, the Corps of Engineers now usually proposes that the entrance channel to a small-boat harbor, even when the harbor depth is less than 14 ft., be planned for a least depth of 14 ft. when it is so exposed that use of a small hopper dredge for maintenance dredging is indicated.

When a hopper dredge is used, the dredged material is usually disposed of by dumping in deep water offshore. In many cases, when the distance to a naturally deep dumping area is so great as to make that method uneconomical, artificial dumping basins in protected water closer to the work are dredged with a hydraulic pipe-line dredge, which then removes the material dumped into the basin by the hopper dredges and pumps it ashore or into other areas of the waterway. This method has been used in the Delaware River and Tampa Harbor.

In at least two cases, hopper dredges have been successfully used to remove rock. In 1927-28, the entrance channel to Miami Harbor, Florida, was deepened to then-project depth of 25 ft. by removing some 900,000 cubic yards of material, about 30 percent of which was limestone. The rock was first surface or "doby" blasted; bundles of 5 or 6 pounds of 60 percent dynamite were tied to a heavy cord about 5 ft. apart; the cord was then laid back and forth across the area to be blasted; one detonator was exploded, and the concussion in the water exploded the rest of the string. The rock so shattered was then removed by the U.S. hopper dredges W. L. Marshall and Dan C. Kingman. A total of 217,650 pounds of dynamite was used at a cost of $62,325.37. The average cost of blasting per cubic yard of total material removed was 6.9 cents. The total unit cost of the work was 23.6 cents a cubic yard. The same method has been used in new-work dredging in Tampa Harbor. Successful use of this method requires a considerable depth of water to hold the shattering effect of the explosive down against the rock. In any work involving blasting, complaints of damage to shore structures are to be expected; whenever blasting is involved, it should be cautiously done, to the end that such complaints may be proved to be unfounded.

Under favorable circumstances, hopper dredges have also been used to remove material from entrance channels by agitation dredging. The material to be removed by this method must be soft silt or mud which will settle out of suspension only slowly; a second prerequisite is that the ebb current must be strong enough and so directed that it will carry most of the suspended material out of the channel to settle out in another area where it will do no harm. In the lower reaches of Savannah Harbor, Georgia, and in the outer-bar section of the entrance channel to Wilmington Harbor, North Carolina, hopper dredges have been used to pump such materials during the ebb flow through the bins and overboard through the scuppers, allowing the current to carry most of it in suspension out of the channel alinement before it settles to the bottom. During flood flows the dredges removed their loads to offshore dumping areas in the usual way.

When, due to lack of sufficient operating depth or other compelling considerations, inlet or bar dredging cannot be done by a hopper dredge, recourse must be had to the hydraulic pipe-line or the dipper type, despite their disadvantages. In such case, every possible precaution should be taken to minimize the hazards attending such operation. Such precautions commonly include the following:

a. The work should be scheduled for a season in which the maximum of favorable weather conditions is to be expected.

b. The dredge should be large, with as high a freeboard as possible, so that it will be affected as little as may be by ordinary wave action.

c. It should have a high dredging capacity, to minimize the time during which it will be exposed to the hazards of such work.

d. It should, whenever practicable, be used only to open up the minimum cut as to depth and width required to give access to a hopper dredge to complete the work to full project dimensions.

e. Before engaging in the inlet channel dredging, a safe haven should be provided into which the dredge and attendant plant can be quickly moved in case of danger.

f. The dredge should work from the shoreward waterway seaward, care being taken to keep the channel behind it open for a quick retreat to safety if bad weather threatens. Rapid shoaling of the channel behind the dredge has on occasion been allowed to threaten to close that avenue of escape.

g. Ample towboat service should be available at all times to move the dredge and its pipe line and attendant plant to safety on short notice.

h. Special care should be taken to emphasize and enforce all safety regulations on the dredge, pipe line, and attendant plant, and to maintain all facilities in readiness at all times for an emergency move.

i. If the dredging involves the creation of a new inlet channel to be protected by jetties, the jetting should if practicable be provided before the dredging is done, in order that the dredge may avail itself of their protection during its work.

When the dredging involves making a new cut through a barrier beach from a coastal waterway into the ocean, certain precautions should be observed in the final opening of the seaward end of the cut, particularly when the tidal range is considerable. It is good practice to carry the cut as close as possible to the high-water line on the beach before cutting through, and to provide some excess depth in the section of cut immediately back of the beach. The break-through is best made when the tide on the ocean side has turned to flood, and just as the water levels on the beach and in the cut become about equal. In this way the current through the newly made opening is at a minimum when the cut is opened; whatever current develops as the tide rises will set in rather than out, tending to carry any items of plant that may break loose inward instead of seaward. If, as is often the case, high velocities develop in the opening, with rapid erosion of the barrier plug, the material carried inward will settle out in the excess depth provided before cutting through, with a minimum of danger that it will shoal the channel sufficiently to obstruct withdrawal of the dredge and attendant plant in case of need. Such shoaling should be carefully watched, and the dredge moved to safety if its escape seems to be threatened.

In many inlets, active movement of beach and bottom material is to be expected, with rapid erosion at some points and shoaling in others. Such inlets are usually characterized by a crescent-shaped offshore bar, over which the natural shallow channel tends to shift from one alinement to another. When a dredged channel traverses such an inlet and bar, it must be expected that, unless jetties be provided, rapid shoaling will take place in some parts of the channel. It is usual to forestall frequent maintenance dredging of such a channel by providing, at the critical points, overdepth and overwidth in which shoaling material may accumulate for some time before encroaching on the project depth and width. A careful study of the given case, and an intelligent distribution of such "advance maintenance" dredging, may materially reduce the frequency and cost of maintaining the navigable depth and alinement of the channel.

In dredging in inlets, special consideration should be given to the disposal of the dredged material. Prior to undertaking the dredging, a careful study of the conditions should be made; the disposal of the spoil should be so planned in advance as to result in the maximum of advantage and the minimum of disadvantage. When the work is to be done with a hopper dredge, the spoil will be deposited either in deep water offshore or in deep holes in the inside waterway; the temptation to use the latter method to save a longer run to an ocean dump should usually be resisted, since the very existence of such a deep hole is usually prima facie evidence of current activity that will probably remove the dumped material and redistribute it elsewhere in the waterway -- probably largely in the channel from which it was originally removed. If the run to an offshore dump is uneconomically long, it will usually be preferable to dredge a dumping area in shallow inside waters with a hydraulic pipe-line dredge, rather than to use a naturally deep hole.

If a pipe-line dredge is used, the safest place for the dredged material is ashore, to fill in marsh areas, replenish an eroding beach, build out land for useful purposes, or as otherwise indicated by the conditions in the individual case. Care should be exercised to place the material far enough from the edges of the cut so that subsequent widening of the cut by wave and current action will not reach the deposit. If a predominant littoral drift exists along the shore, dredged material can often profitably be placed on or near the beach on the downdrift side of the inlet, so that it will be carried away from the inlet along the beach; this is especially true when the inlet entrance is jettied and when active erosion of the downdrift beach is in progress or may be expected. If the material must be deposited in inside waters, it should be placed in such amounts and on such alinements as will at least not adversely affect the direction and intensity of the tidal currents, and, if possible, will favorably affect them. The carrying capacity of the tidal waterway should not be so reduced as to diminish the tidal range and prism of the waterway landward of the work. The complexity of the hydraulics of most tidal inlets is such that, if the material is not to be simply and safely deposited ashore, a major study of the place and manner of its disposal is essential if unexpected damage to the waterway is not to be caused.

Many of the special aspects of dredging in tidal inlets are illustrated by some work done by the Corps of Engineers for the Navy at Ponce de Leon Inlet, Florida, during the recent war. In its natural state, Ponce de Leon Inlet is a fairly stable opening through a barrier beach near New Smyrna, on the east coast of Florida, through which Halifax River from the north and Hillsborough River from the south empty into the ocean. At its seaward entrance is the usual crescent-shaped offshore bar, over which mean-low-water depths of 1 to 5 feet prevail. Prior to the dredging, the least width of the inlet between low-water lines was about 1,800 ft.; in the north one-third of that width, a natural channel up to 37 ft. deep and 450 ft. wide between 5 ft. depth contours extended seaward; the south two-third was generally less than 3 ft. deep. The natural channel crossed the offshore bar generally perpendicularly to the shore, widening gradually to a maximum of 1,000 ft., and shoaling progressively to depths of 3.5 to 5.0 ft. over the crest of the bar about 1/2 mile offshore. At that point the channel angled sharply to the southeast, evidencing the fact that at that point the heavy preponderant southward littoral drift crossed the channel from north to south.

Along the alinement of that natural channel, a channel 20 ft. deep (14 ft. plus 6 ft. of overdepth), 200 ft. wide, and about 6,000 ft. long was to be dredged to the 20-ft. depth contour on the seaward face of the bar. A hopper dredge could not be used because of inadequate depth over the shoal; the 22-in. hydraulic pipeline dredge "General," owned by the Arundel Corporation, was leased for the work. The dredge began work at the shore end of the inlet channel on May 15, 1943; with generally favorable weather the dredge reached the crest of the bar on June 11. The weather then changed, and it was necessary to pull the dredge back into the inside waterway, where it worked until July 1. It was then moved back to the outer bar; on July 2 the swinging cable parted, and it was too rough to make repairs. On July 3 the dredge was again pulled in to safety; the company then refused to do any further work on the bar, and the contract was terminated on July 7, leaving the outer end of the work unfinished, with a least depth of 8 to 9 ft. over the crest of the bar. The total amount of material removed was 522,000 cubic yards, all soft.

The dredged material was placed in two areas. Part of it was placed off the north land point of the inlet to form a dredged mole parallel to the channel and extending about 3,800 ft. seaward from the original high-water shore line. The rest was placed off the south land point so as to extend it about 1,100 ft. from the high-water line into the inlet, reducing the width of the inlet by nearly one-half.

The material placed in the mole north of and parallel to the channel was straightway carried back southward by the littoral drift; within 6 months the mole had practically disappeared. Most of the material was carried back into the dredged channel, which shoaled rapidly from its north edge, especially in the section crossing the crest of the offshore bar. By May 1944, the crest of the bar had been restored to its original predredging elevation. The shoreward half of the channel shoaled generally less rapidly; after nearly 1 year it still retained depths of from 16 to 20 ft. instead of predredging depths of 8 to 10 ft. As the dredged channel shoaled along its north edge, the south edge was scoured, with the result that the deepest available channel at the end of the first year extended seaward from the gorge on an alinement about 6° to the southeast of the original dredged cut. About 330,000 cubic yards of material were deposited in the dredged channel cut within 1 year after the original dredging.

In summary, the following points are recommended for consideration by those responsible for dredging in inlets on sandy coasts:

a. If adequate initial depth is available and the material to be removed is soft, the work can most safely be done with a seagoing hopper dredge.

b. If a hydraulic pipe-line or a bucket dredge must be used, it should be carefully selected for its suitability to the work, every possible precaution should be taken to ensure its safety, and it should be used only to open up a pilot cut of sufficient depth and width to permit a seagoing hopper dredge to complete the dredging to full planned dimensions.

c. Dredged material should be so disposed as to produce a maximum of benefits and a minimum of adverse results. This will frequently involve a careful and intelligent study of all pertinent factors.

d. A carefully considered use of overwidth and overdepth advance-maintenance dredging can often considerably reduce the annual cost of maintaining an inlet channel.