Chapter 15

SAND BY-PASSING PLANT AT SALINA CRUZ, MEXICO*

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The Port of Salina Cruz, in the State of Oaxaca, Mexico is entirely artificial. It consists of an outer harbor and a basin divided by two large wharves on which stand six double warehouses. For a time, jurisdiction on this port was equally divided between the Administration of Free Ports and the Federal Fiscal Authorities, but at present, by Presidential decree, the entire port is under our Free Ports Administration. On the west end of the outer harbor, a dry dock able to handle boats up to 18,000 tons has been operating since it was built. On the same side of the outer harbor, terminal installations of Petroleos Mexicanos handle all shipments of crude oil and gasoline for the Pacific Coast of the country.

The English concern that originally planned the port works of Salina Cruz, had in mind only the breakwater starting from Beacon Hill and extending sufficiently into the sea to protect the entire length of the wharves against the seas and winds from the south, thus forming an outer harbor with its entrance on the east. However, when construction of the breakwater had progressed to the point where it now turns southward, it was observed that, during stormy weather and heavy seas from the south, the space between this section of the breakwater and the wharves, or what was then becoming an outer harbor, would fill up with sand. The English engineers grasped the enormous importance of the sand drift from the west. Upon realizing this, they changed the direction of the breakwater towards the open sea and were forced to construct another breakwater on the eastern side, thus forming the present outer harbor. Sand began to deposit from Beach Hill to the extreme point of the breakwater forming a huge sand fill, sometimes filling to depths up to 15 fathoms. Once this deposit started to accumulate to overflowing, sand would invade the outer harbor making it necessary to keep a dredge working continuously, as it has in the past 40 years, in order to pump it towards the open sea. This work has cost the Mexican Government over 50 million pesos with the bay constantly running a risk, as the sand, accumulating in the outer harbor, closes up the channel and makes navigation difficult and dangerous through tortuous channels from the entrance to the basin proper.

*(Editor's Note: This installation is considered to be one of the first large scale stationary dredges in the world. The effectiveness of this plant in accomplishing its purpose is not known at this time; however, its performance is being closely observed by the Beach Erosion Board, and it is suggested that future publications of that agency be consulted for an evaluation of the effectiveness of this unique installation.)

During the last few years dredging has been sporadic, a fact which has, unfortunately, smirched the reputation of the port since large boats cannot dock there, thus paralyzing the commercial development of the entire region. It is well known that Salina Cruz and Puerto Mexico, each on the terminals of the Isthmus Railroad, are geographically strategic points in world communications and are very important throughways to increase international trade and specially United States intercoastal trade.

The sand drift from western seas that kept clogging the bay of Salina Cruz stood as a great challenge to Mexican engineering. It has been the good luck of the Administrative Board of Free Ports to be able to attack the problem in search of a solution even before the Ministry of Marine was created.

The work has progressed with full approval of various Presidents of the Republic who have shown interest in our plans, specially President Miguel Aleman who has given full support to the program. We are also greatly indebted to senor Beteta, Minister of Finance, whose staunch backing has been unfailing.

The sand drift comes from a western direction (not pushed by coastal sea currents) but impelled by the dynamic action of the waves that all year round hit the coast at an acute angle pushing the sand upward and towards the east, then receding on the inclined plane of the beach with a rip tide action. This continuous up and down motion with an eastern trend constitutes the eternal drift of sands along the coast, until the shoreline of Chiapas is reached; there, waves hitting the beach at a right angle push the sand up the beach and back to sea, without angle displacement.

The continuous action of the waves pushing the sands is the cause of the filling-up of the area between Beacon Hill and the far point of the breakwater referred to above, sometimes drifting so heavily into the outer harbor that it threatened to fill it up completely and close it to navigation. The same action has created coastal sand bars as in front of Juchitan, of such heights as to form lagoons with only small outlets for rivers and tidal currents.

At Salina Cruz Bay no strong tidal current is felt due to the small volume of water within the outer harbor and the basin; therefore, no open channel has ever been kept open by currents and the eternally drifting sand from the west has the tendency to fill up the outer harbor and block its entry.

The Administration of Free Ports faced this problem and, after considerable investigation arrived at the decision to erect at the land end of the western breakwater, on the same side of the drifting

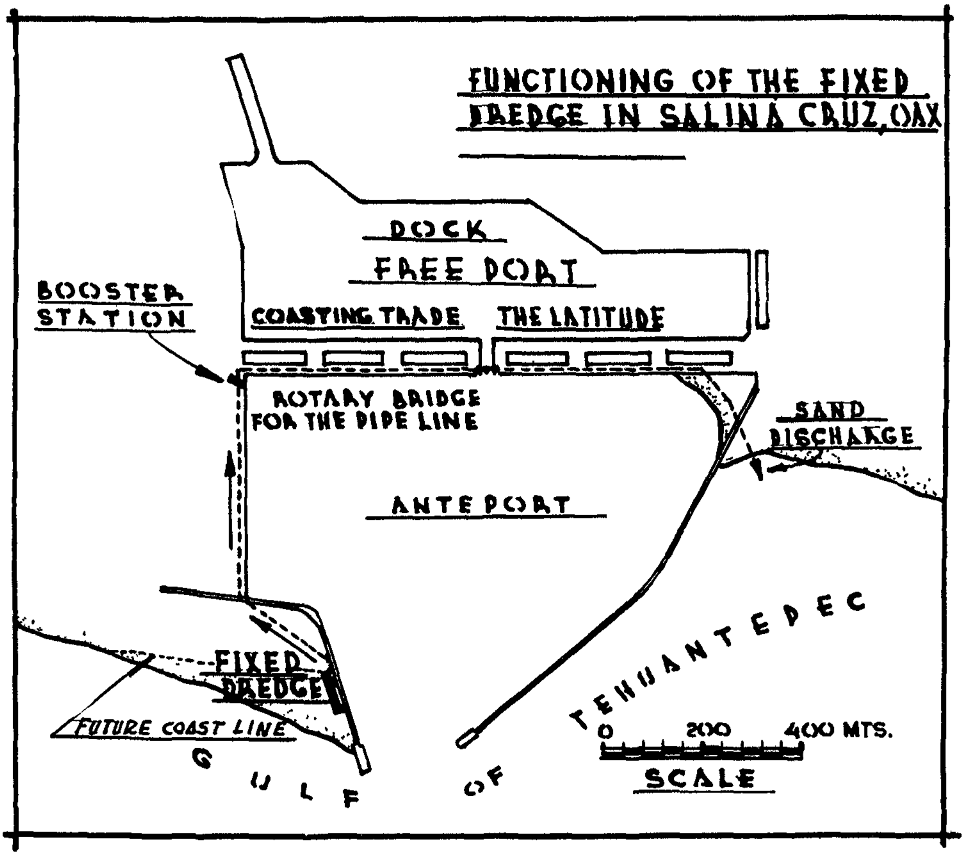

Fig. 1
Location of Salina Cruz stationary dredge and discharge pipe line.

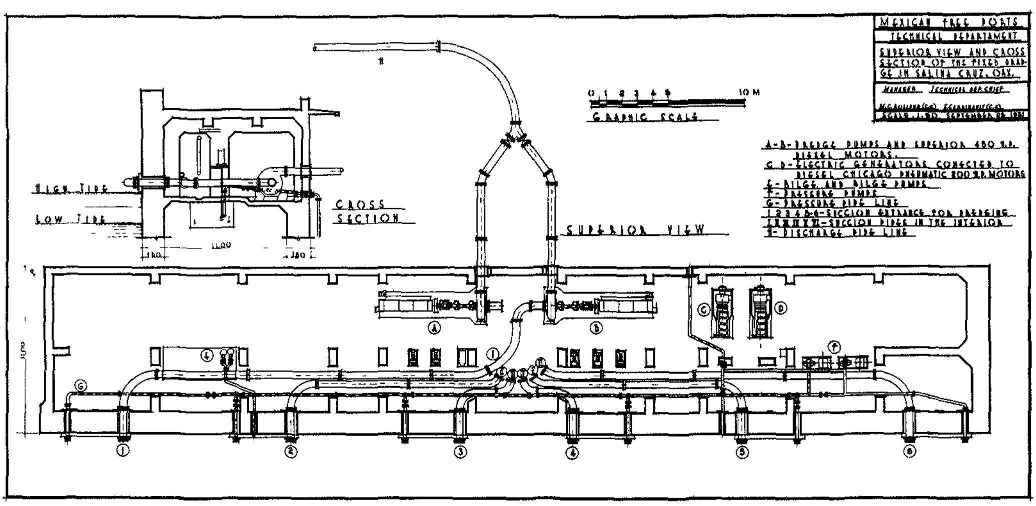

Fig. 2
Floor plan of machinery house.

sand movement, a solid construction as illustrated by the enclosed drawing (Fig. 1) to house powerful suction pumps to carry away sand accumulated through a pipeline following the shore of the outer harbor, past the front of wharves, to the other side of the eastern breakwater where it is discharged on the beach, there to be washed further east by the sea.

Careful preliminary studies were prepared and checked by expert consultants brought from the United States; finally, sufficient appropriation was obtained from the Government to build three great blocks, each 65 ft. long by 39 ft. wide, aligned parallel to the breakwater. These great blocks with walls $4\frac{1}{2}$ ft. thick, with transversal partitions of the same thickness, were sunk, taking advantage of their own weight upon extraction of the sand collected in their interiors. This process is called "Chinese Well" and we understand this is the first time it has been applied in such a large scale in Mexico and, for that matter, in the Continent. The operation was carried out successfully, although not easily. The three blocks sank in perfect alignment with their bottoms resting 49 ft. below low tide.

On top of these blocks a superstructure was built and finished into a great 197 ft. long enclosed space to install standard dredging machinery, i.e. pumps, electric motors and generators, refrigeration pumps, vacuum pumps, etc. This machinery, however, has been installed in duplicate, to insure unfailing performance (Fig. 2). The pumps absorb sand on the sea front through six suction pipes that move fan shape by special swivel-joint connections, covering with their upward, downward and sideways movement, about 197 ft. or the entire length of the construction, digging out a great ditch 32 ft. deep where eastward drifting sand is deposited. It is a veritable sand trap.

Suction pipes are run by special derricks operated from a housing on top of the main building, each movement of the pipe, (upward, sideward and downward) originating in electric winches controlled by the operator sitting at a window between two of the suction pipes (Fig. 3). The sand then travels through a pipeline installed between the dredge and breakwater directly to where wharves begin, at the side of a substation which is in reality a duplicate of the main station, with identical motors and pumps. The pipeline then passes in front of warehouses and across the entrance of the eastern breakwater, thus transporting the sand for 6,600 ft. When traffic in the port becomes heavier, it shall be necessary to continue this pipeline from the substation, across firm land circling the basin, in order to avoid the swing bridge over the entrance.

This type of installation, with the machinery inside a building but doing actually the same work as a floating dredge does, is what has promoted us to call it a "stationary dredge". Its operation is quite simple and inexpensive since, to transport 35 cu. ft. of sand

(1 cubic meter) costs only twenty cents Mexican currency, from where the sand is pumped, to the other end of the pipeline, as against two to three pesos for the same volume, when done by a floating dredge.

Fig. 3
Preliminary arrangement to control moving sand

Personnel required for the operation is only a dredger, an electrician and assistants, also overseers.

The dredge does not let the sand pass on into the bay and so, when the installations begin to function normally, it will be time to dredge out the bay completely, wherein are now not less than 2 to 3 million cubic meters of sand that must be extracted before the port can be reasonably operated as such.

Without the stationary dredge, the extraction of sand with a floating dredge circulating in the outer harbor would be a never ending operation, as demonstrated by 40 years of experience. On the other hand, the stationary dredge planned by us and developed, thanks to the backing of the President, represents a new method of solving economically many problems represented by drifting sand. We expect, therefore, great international interest in this experiment considering that several other ports are in the same unfavorable condition and, if we are as successful as anticipated, we shall have contributed in a large measure to the betterment of world's production and trade.

Fig. 4
Half section of swing bridge across the entrance to the basin, in open position.

Fig. 5
Complete swing bridge in closed position.

This stationary dredge has cost ten million pesos of which six represent machinery from Werf Conrad, a Dutch factory specializing in dredges. This firm greatly aided us with their vast experience in the proper interpretation of our blue prints. The machinery was traded for Mexican sugar.

The engineering construction problem was ably carried out by "Obras Portuarias", S.A., with devotion, constancy and even sacrifice, in a relentless struggle against the sea, to achieve in the end success that deserves honorable mention. We should not leave out mention of another important cooperation, that of the Department of Communications to whom we owe a well-constructed, paved highway from the town of Salina Cruz to the stationary dredge, thus communicating the dry dock, oil terminal, and the dredge, all federal institutions highly important to the economy of the region.

STEEL PIPELINE AND SWING BRIDGE

The pipeline for transporting the sand through its 6,600 ft. length is made of steel 7 millimeters thick, flanged and jointed, and waterproofed. To cross the entrance from the outer harbor to the inner basin, a very light swing bridge was constructed where the pipeline acts as resistance axis, surrounded by a light iron web to add rigidity to the structure (Figs. 4 and 5). Two men, one on each side of the canal, handle each half of the bridge and tighten the central joint formed by a rubber section in the pipeline. The operation takes approximately ten minutes.

MACHINERY

The stationary dredge contains the following equipment:

1. Two "Superior" U.S. made diesel motors, each 450 H.P. to operate two dredging pumps, equipped with 18 in. pipes.

2. Two electric generators driven by 200 H.P. diesel motors to develop power required to operate all auxiliary machinery and winches.

3. Two duplex pumps, for refrigeration, lubrication, etc.

4. Two drain pumps.

5. Switchboard

Each pump functions by connecting a rubber, flexible suction tube to each of the six pipes coupled to the exterior of the machinery housing; these are coupled in turn, to the six suction tubes on the outside of the stationary dredge (Fig. 2). The water pressure pump injects high pressure water separately to each suction pipe to agitate the sand and facilitate the suction process. On the $4\frac{1}{2}$ ft. thick block wall facing the sea and clamped by steel plates, six suction pipes are installed, moving upward, sideward and downwards, fanning thoroughly between pipes to dredge effectively the entire front of the stationary dredge.

Vertical and lateral movements of pipes are transmitted by cables from the top housing of the machinery building. Each suction pipe being equipped with three winches - there is a total of 18 winches. The operation of each suction pipe is controlled electrically by a dredge operator sitting at a window between two suction pipes.

In the stationary dredge the pump's two outlet pipes empty into the pipeline leading straight to the booster station at the end of the docks, crossing the access to the basin over the swing bridge (Figs. 4 and 5) and emptying, at a point at the head of the eastern breakwater, into the sea that carries the sand away to the east towards Chiapas.

BOOSTER STATION

The object of the booster station is to aid the movement of sand-laden water. It is equipped with two 450 H.P. motor driven pumps identical to those at the dredge. The station also is provided with cooling, fuel and refrigerating pumps, etc. The source of energy for these operations is the generators at the stationary dredge.

The 18 in. steel pipeline is open-installed in order to facilitate its inspection. It was first planned to cross the bay by means of an inverted syphon, but the suggestion was abandoned upon consideration of the possibility of it being subject to corrosion by salt water, precisely at a dangerous point like the channel.

SPUR DIKE

On the west side of the stationary dredge, at the foot of Beacon Hill, we are constructing a spur dike by the most economical standards, which we intend should hold back drifting sands from the west, to keep from reaching the dredge, thus saving considerable wear. Sometimes the bottom of the sand deposit forming at the head of the spur dike is less than 16 to 19 ft., due to the eastern drifting sand being pushed by the rip tide away from the deposit formed on the western side of the spur dike. This will be the only sand that requires dredging. We have calculated that a spur dike 1,600 to 2,000 ft. long can withhold sand for a period of 200 years but, when the stored sand forms a beach near the end of the spur dike, the rip tides force sand past the dike as explained above. This is the critical safety point of the spur dike against the drifting sand.

We need to determine, under actual working conditions, whether the cost of the spur dike is cheaper than the cost of dredging stored sand; if higher, it will be best to allow the sand to reach the dredge and be pumped out by it. Experience will tell. It is advisable, however, to consider the construction of the dike even if it is costlier than pumping sand, because it would save the machinery of the dredge considerable wear. Even so, whether with dike and dredge or by dredge alone, drifting sand will be stopped from entering the bay of Salina Cruz.

PRE-OPERATION TO START THE DREDGE WORKING

Between the stationary dredge and the sea, a big volume of sand stood where the waves have been pounding for ages. To start construction of the stationary dredge it was first necessary to raise a bank reinforced by wooden piling. After the construction was finished and

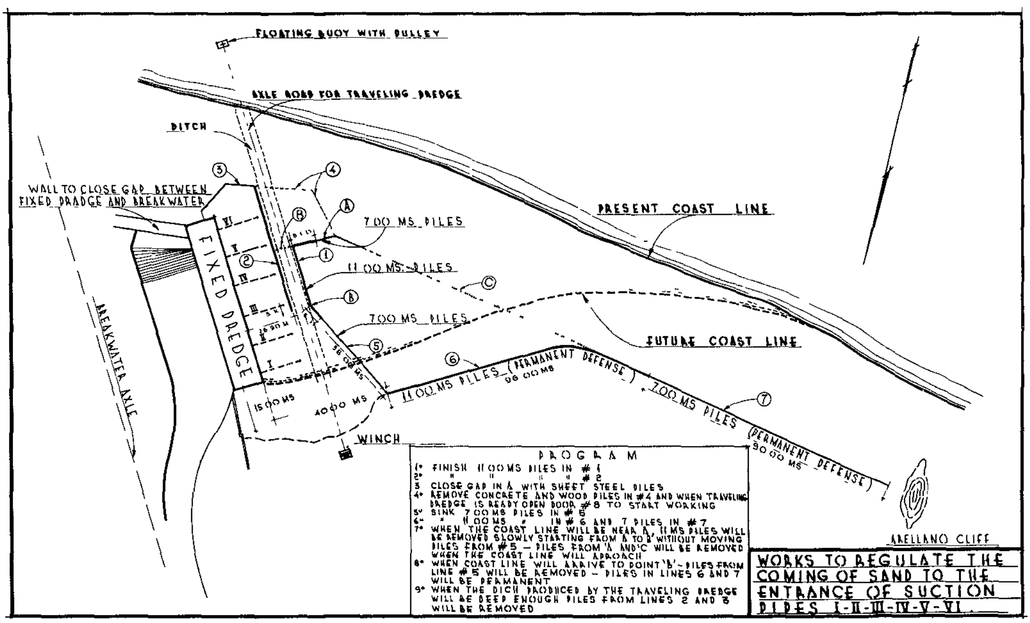

Fig. 6
Drawing showing position of piling installed to control impact of sifting sand on the stationary dredge, considering the great sand deposit created between the dredge and the ocean.

the machinery installed, tests were made to pump water and sand and, even sinking of the suction pipes to extract sand from 32 ft. depths. The next step was the opening of the lagoon, thus formed by the banking of sand, to the ocean front so as to sink the suction pipes into the sea. This entailed a strenuous operation because each time the opening was made, sand rushed into the lagoon in such quantities that it was filled up and the pipes stopped functioning. After several trials and arduous work, we finally had to construct passageways of reinforced concrete sheetpiling, in 23 and 32 ft. lengths, in front of the pipes, through which a drag scraper operates pulled by a winch and guided by steel cables passing over a pulley installed on a float anchored at sea (Fig. 6). This drag scraper or "travelling dredge" is actually digging a deep ditch across the beach in which drifting sands are trapped and carried to suction pipes number 1 and 2 (Fig. 2), then pumped off by the dredge. The sheetpiling will be displaced gradually, according to plan, but always leaving well defined accesses for sand until their greater volume is controlled to avoid fast precipitation into the lagoon, thereby throwing the suction pipes out of commission.

We were compelled to recourse to this operation because, if the large deposit of sand to be removed had had free access to the dredge, no machinery made would have been able to handle it. The machinery is calculated to remove normal volumes of sand drifting from the west; therefore, we had to hold back all accumulated sand and extract it gradually, at the same time that we dredge out other drifting sand.

The problem therefore of breaking out a deep ditch on the natural barrier built by the pounding sea has been a difficult one to solve, an arduous job to carry out and, the only solution to keep the sand from drifting further into the bay and to bring it within reach of the suction pipes. We understand this to be an entirely novel problem coming within the scope of the technique of maritime construction.