

CHAPTER 25  
BREAKWATER CONSTRUCTION

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INTRODUCTION

Upon receipt of an invitation to participate in this conference and present a paper on the subject of Breakwater Construction, I was happy to accept, feeling that I would benefit to a far greater degree than my contribution to a subject in which I, and the concern which I represent, have had a deep interest for many years.

Our experience embraces some of the major jetty and sea wall construction in San Francisco Bay, viz: Treasure Island, Mare Island, Alameda Naval Air Station, Sacramento and San Joaquin River bank protection and other jetties along the Northern California Coast, including Crescent City.

This paper is limited to breakwater construction on the basis of our experience previously mentioned. The subject has been divided into two parts, namely, (1) construction of jetties, or breakwaters which can be built by use of floating equipment and (2) construction of jetties which are not practicable to be built by use of floating equipment.

I shall preface my presentation by presuming that we have before us a design of jetty, (1) indicating that borings show a substantial depth of mud that is unstable, but which -- by the addition of a blanket of quarry rock fines will stabilize sufficiently to carry the weight of the jetty without movement, (2) a portion showing mud to a depth that it will not stabilize requiring removal by dredging.

CONSTRUCTION OF JETTIES BY FLOATING EQUIPMENT

The first requirement is the location of a deposit of stone which will produce a sufficient quantity of rock that is durable, not subject to disintegration by the action of air and sea water, and will withstand the soundness tests specified for stone which will be used for armor or face and cap of the jetty. It is obviously desirable that the location of the deposit be as near as possible to a navigable waterway to reduce to a minimum transportation cost from quarry face to barges.

Production of stone. As all deposits vary in formation no uniform procedure will apply to all quarries or deposits. In the process of quarrying rock, care should be exercised to conduct the blasting operation in such a manner that will produce the maximum amount of the larger pieces of rock to be used for armor or face and cap stone.

The armor or face and cap stone should be stockpiled for use when required. Rock fines for blanket material can be produced by passing smaller material over a grizzly (the "thru" material being blanket, and the "overs" will combine with the core rock). Core rock is usually abundant in quantity due to the smaller size.

Loading onto barges. In our operations we have built adjustable loading ramps which are raised and lowered to compensate for tide, by means of electrically powered hoists designed to permit rock trucks to back up the ramp and dump directly onto the deck of the barges, which method is suitable for blanket, core and smaller sizes of armor or face rock. For rock that is larger and of such weight that dumping would result in damage to the deck of the barge, loading is accomplished by swinging the individual pieces aboard by crane with the use of slings. Skips have also been employed for loading. At our McNear Quarry where the core rock is the product of material passing through a 48 in. x 60 in. jaw crusher, scalped over a screen which removes non-specification fines, the result-

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ing product about 24 in. maximum is loaded directly onto the barges by means of rubber conveyor belt.

Transportation by floating equipment. Transportation from quarry or loading point to site involves use of barges designed strong enough to withstand impact of dumping rock thereon, with decks protected by heavy wood sheathing. Tug boats are used to tow barges to the jobsite.

Placement from floating equipment. (Bottom dump barge.) Placement of blanket material and core rock by bottom dump barge is accomplished by securing it alongside a mooring barge equipped with winches and held by four anchors running from its four corners to enable accurate positioning of the dump barge. This procedure is desirable when the core is approaching the surface in order to obtain full coverage along the line of the jetty and maintain the slopes of the core. In deep water which affords a wide base, the major tonnage may be placed within the lines by dumping while the tow is under way.

Flat deck barges -- unloading by bulldozer. Another method utilized for placement of blanket material and core rock has been to employ a tractor bulldozer to push the rock over the side of a flat-deck barge. A mooring barge to moor and control positioning of the barge in the same manner as described for the bottom dump barge is required for this method. The tractor is kept on the mooring barge and walks aboard the rock barge to unload and then returns by means of a ramp designed to accommodate the height of the rock barge when unloaded.

Conveyor barges. In connection with the jetties built by our company in San Francisco Bay, we designed and built self unloading hopper-conveyor barges, the conveyor of which discharges rock over the bow end of the barge, hinged to permit vertical movement which permits bringing the top of the core mound to a specified elevation. Positioning of the barge on the center line of the jetty is again accomplished by use of a mooring barge. Power for driving the conveyor or air equipment is either installed on the hopper-conveyor barge if by power units, or if electric by installing electric generating and air compressor equipment on the mooring barge.

The conveyor barge consisted of a steel hopper mounted on the dock of a steel barge. The bottom of the hopper being formed by removable panels. A 48 in. conveyor was installed under the panels. The operation consisted of removing the first panel at the bow end of the barge by means of a cable running from the control platform over a sheave on a movable bridge which travels the length of the hopper. The removal of each panel permits the rock supported by it to flow onto the conveyor belt out over the head pulley into the water, exposing the next panel and repeating until unloaded. The advantages of this method of placement appear to be; accurate control of positioning, building the core to full section rapidly thereby producing a rapid concentration of weight, which permits the mass to find its bottom where underlaid by mud. If there is settlement, the core can be built up by the addition of more material long before the armor stone is placed. In the placing of material by conveyor there is always the natural segregation, the fines remaining in the center of the core and the coarser material going to the outside of the mound which is the result desired.

Placement by this method is particularly desirable for building the core in comparatively shallow water and for completing the core to the desired elevation above water where bottom dumping must cease because of lack of floatation. It is a more rapid and accurate method than placement by derrick or crane.

Placement of toe, armor and cap stone. In order to withstand the action of heavy seas and afford the protection for which jetties and breakwaters are designed, the armor and cap stones even in harbors and bays, are specified as individual pieces of substantial weight ranging from 2 to 5 tons for harbor work and considerably heavier for jetties exposed to the open sea.

Placement of this rock therefore requires weight handling equipment consisting of derrick or crane barges of adequate capacity. The crane barge is anchored parallel to the center line of the jetty upon which the core has now been completed to the designed elevation. Anchoring is accomplished by placing two adequate

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anchors offshore from the jetty with anchor cables running through sheaves on the offshore corners of the crane barge to power driven winches. Two similar cables run from sheaves on the jetty side of the barge to dead-men placed in the core rock or to anchors placed on the opposite side of the jetty. The rock barge is moored alongside and placement proceeds by the crane lifting the individual pieces from the rock barge and placing toe rock along the line away from and parallel to the core. This line being marked by range stakes. Armor stone is next placed on the toe and core and continues up the slope of the core below water until it emerges.

Placement of armor stone above water is usually specified to provide a given thickness of armor or face, to be keyed in place and built to a specified slope with a minimum of voids as far as practicable within the range of the pieces of rock specified. Exercise of care in selection of size and shape of each piece is therefore required. Templates may be provided to guide the crane operator in maintaining thickness and slope.

Cap stone is finally placed across the top of the jetty to the specified elevation again in such a manner that as far as practicable keying into the armor and minimum of voids is maintained. The cranes are equipped with rock grapples which seize and lift an individual piece up to a weight and size limited by the capacity of the grapple and the weight lifting capacity of the crane. Larger stones are handled by use of steel wire rope slings.

It should be pointed out that the above methods wherein barges are moored alongside are only practical in comparatively quiet water. During stormy weather or when heavy swells are running which would cause the barges to pound against each other the work must be suspended in order to avoid loss of or damage to barges and equipment of substantial value. Fortunately after the core is built a lee is thereby provided which except in extremely heavy weather permits work to proceed on that side.

### CONSTRUCTION OF JETTIES WHICH ARE NOT PRACTICABLE TO BE BUILT BY USE OF FLOATING EQUIPMENT

This situation occurs under two conditions, (1) the obvious one where insufficient or no water is available for floatation such as bank protection along shallow beaches and river banks, and (2) the other condition of building out into the open sea at locations where heavy seas or storms are to be encountered during the major part of the year, such as the condition to be found along the Northern Pacific Coast. Under this latter condition at locations where the weather records show that one may expect four or five months out of the year that swells have abated sufficiently to where they will not wash a 100 ton crane overboard, jetties have been built by use of the top of the jetty as the travelway for hauling and placement equipment.

This method entails building a roadway on the top of the jetty by filling the voids with whatever sized material will accomplish and provide a smooth surface as the jetty progresses seaward and possibly paving with a thick portland cement concrete slab. The crane must have sufficient capacity and reach to place the core rock along the centerline and to the specified distance from centerline, and to place the armor and cap stone. As the design of ocean jetties specify weight of individual pieces for armor to range from 7 to 15 tons, and larger for the seaward slopes rock grapples are used only on core rock. Armor and cap stone are handled with slings, fashioned so as to trip and release the rock when positioned.

The rock is transported over the top of the paved jetty to the crane at the end of the jetty by trucks. At intervals along the jetty it is widened on the lee side to provide turn outs for trucks to turn around after dumping at the crane, and for passing other trucks.

Another method of constructing jetties in the open sea has been to build a pile railroad trestle from the shore for the length of jetty to be built. Transportation and placement being accomplished by railroad flat cars and rail unloading and placing equipment.

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Obviously the availability of deposit is desired to be close to the site of the jetty and the same method of quarrying previously described should be followed.

It will be appreciated that because of the many varying conditions of design required to meet existing physical conditions, my presentation of this subject may have overlooked some phases or methods not embraced in our experience.