REHABILITATION OF WHARVES AND PIERS ARMY BASE, SOUTH BOSTON, MASS. — CONSTRUCTION

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As a representative of the contractor, Merritt-Chapman & Scott Corporation, it is now my privilege to explain how the plans and specifications of the owners and engineers have been translated into a physical structure.

As you probably already are aware from published reports in technical publications two basic problems confronted the contractor in this major project:

(1) Construction work required close coordination with ship movements to keep disruption of pier operations to a minimum.

(2) A massive subaqueous gravity wall and cantilever deck more than a mile in over-all length had to be constructed without visible anchorage.

The contractor's phase of the project started May 13, 1955, when Merritt-Chapman & Scott was the successful low bidder, with an estimate of $7,995,582.

In addition to the wharf and pier rehabilitation, which increased the width of the entire open pier by 27 feet, the project entailed rehabilitation of the Wharf and Pier Sheds. For the purposes of tonight's discussion, we will confine our review to the gravity wall and cantilever slab structures. In the interest of clarity, we will discuss this phase of the work in chronological order, starting with preparation of the bottom and design of the special forms for the work. I think it should be pointed out in passing that to our knowledge this job represents a unique construction "first" in terms of underwater concreting.

The construction of conventional bridge piers, drydocks, etc., by

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tremie concreting is comparatively routine when compared with the problems of building a geometrical molded form underwater, as required in the case of the Boston Army Base. Add to this the fact that no visible anchorages were provided in the specifications, and you begin to have an appreciation of the trail blazing construction techniques that were required.

As already indicated, the physical proportions of the gravity wall, and the volume of materials required, were in themselves impressive. Running around the perimeter of the pier for a distance of approximately 5,500 feet, the wall rises 52 feet from a minimum elevation of —35 ft. below mean low water. It is 27 feet wide at the base and narrows to eight feet in width at mean high water line or elevation +9.5. Construction of the wall and its 27-foot-wide cantilevered deck will require a total of approximately 180,000 cubic yards of concrete and 4,100,000 lbs. of reinforcing steel

Design of the special gravity wall forms obviously represented the major consideration in all planning for this job. Upon award of the contract, Merritt-Chapman & Scott proceeded to finalize and detail the preliminary drawings that had been developed during the estimating period.

The gravity wall forms were uniformly 49′ 6″ high, with 5′ 3″ extensions that could be installed at the toe wherever depth required. In essence, these forms were extremely simple. Each set was 94′ 6″ long which, for ease of handling, was designed in three sections—two of them 34′-2″ in length, and the other 26′-2″.

The face of the forms was fashioned from light steel plate, stiffened at approximately two foot centers with horizontal steel joists. This panel construction was backed by vertical triangular shaped trusses made up of wide flange beams and "K" web bracing. The trusses were spaced approximately 10′ 6″ on center and tied longitudinally with horizontal bracing. Yokes attached to the extremities of the outboard chord member of each truss provided guides for spud piles with which the forms were permanently positioned for concreting.

A simple interlocking arrangement along the edges of the face of the form permitted each section to be joined to the other by a single length of flat web sheet piling.

This special design greatly expedited alignment of the forms. Alignment of the outboard chord of the truss in a vertical position automatically set the surface of the form at a slope of 4½ on 12, which was the specified batter for the gravity wall.

Once aligned, the forms were pinned in place by driving the spud piles through the yokes to a minimum penetration of 10 feet below the prepared bottom. The steel sheet pile face of the existing pier served as the inboard form. The 26′-2″ length comprised the center section of each set of forms. The outer ends of each of the two 34′-2″ sections were fitted with sheet pile interlocks to receive transverse bulkheads.

The inboard end of the closure bulkheads was secured in place by two vertical triangular-shaped trusses. The vertical truss was joined to the bulkhead by a sheet pile interlock arrangement. Once the bulkhead was positioned, the truss was pinned in place by driving two vertical piles through yokes on its outboard legs.

At bottom the reaction was taken by penetration of the piles into the river bed. At the top, the trusses were tied together by a longitudinal tie rod extending across the top of the form.

Throughout the job it was standard practice to set 94′ 6″ lengths of wall in alternate positions. When filling the gaps, between these alternate sections the previous pours served as end bulkheads. All told Merritt-Chapman & Scott used three sets of forms for the gravity wall, two with end bulkheads and one without.

Concurrently with finalization of the form design, construction activity was being pushed in the field. The Army Base Pier at South Boston is divided into ten berths. Under the terms of the contract governing construction schedules, the contractor could occupy only two berths at a time for construction. Under this schedule, the contractor was required to consider each berth virtually a separate contract since he had to schedule his work entirely in accordance with the availability of idle berths.

Normally, it would be a contractor's practice on a project such as the Boston Army Base Pier to schedule each phase of the work in one continuous operation. In other words, preparation of the bottom would have continued progressively along the length of the pier with construction of the gravity wall following immediately behind. Construction of the cantilever slab similarly would have followed close on the heels of each section of gravity wall.

Since certain berths had to be kept free until released to the contractor, this progressive schedule could not be followed at South Boston.

As a first construction step, pile loading tests were made to establish the length of foundation piling required to support the gravity wall. Each test pile was loaded to 150 tons.

Except for a small section resting directly on rock, the wall is supported throughout its length by three rows of H piles. Along part of Berth 3 the wall rests on rock.

Preparatory to placement of the piles, the bottom was dredged approximately to elevation —37.0. A two foot blanket of gravel was then placed as a bedding for the tremie concrete wall. The inboard row of 14″ bearing piles 89#, spaced 10′-6″ on centers, were driven vertically into the bottom to an average penetration of 25 feet, and imbedded in wall approximately 8′ above the gravel bed. The two outboard rows were driven on a batter toeing outboard and 3′-6″ centers.

Upon completion of the design and details by Merritt-Chapman & Scott construction of the forms was entrusted to Blaw-Knox Company of Pittsburgh, Pa. While the forms had been scheduled for completion in two and a half months, delivery was delayed six months by an acute shortage of wide flange beams. Eventually, warehouse steel had to be used for fabrication, and I need hardly emphasize to you gentlemen the cost entailed.

For convenience in shipment, forms were fabricated sectionally for assembly at the project site. Upon arrival, the component parts were placed aboard barges and welded into complete units.

Accuracy in placement of the forms was insured by a template arrangement extending eight feet beyond the face of the dock's existing sheet piling. Placement was by floating derricks, which could easily handle the approximate 36 tons average weight of each section. Once the top of the form was flush against the template, the outboard chord of the truss was plumb, the form was temporarily secured. Adjoining sections were successively tied together by means of an interlocking sheet pile, and closure bulkheads added. After the entire 94′-6″ section was aligned, the outboard spud piles were driven. This secured the toe of the form. The top of the form was secured by a tie rod anchorage system running beneath the existing deck of the pier. The outboard end of the tie rods, spaced between the master piles, were connected to a strongback, set outboard of the piles.

The inboard end of the tie rod anchorage system posed special problems for the contractor because of limitations imposed upon him by the specifications. Fearing that the pier was in too weakened condition to withstand any lateral forces, the U. S. Army Corps of Engineers had ruled that no anchorage could be secured to the existing structure.

Following a series of proposals submitted by the contractor to the consulting engineers, the following arrangement was arrived at. A row of vertical anchorage piles was driven through holes in the pier deck 80 feet inboard of the existing sheet pile bulkhead, or 40 feet inside the pier shed. The first floor of the shed was only 32 feet high which, together with seven feet leeway below the deck, effectively limited pile lengths to 30 feet.

After being driven, the pile tops were chocked against the existing pier deck, distributing the load between the deck and the fill beneath the pier. 2½″ diameter rods coupled into 116 foot lengths were used to tie gravity wall forms to these anchorage piles.

As a further precaution, the consulting engineers initially directed the contractor to provide an additional anchorage by driving a second row of piles inboard of the first row and connecting them to the first row with another set of tie rods running above the deck. Strain tests taken on the tie rods during the first placement of concrete indicated, however, that this secondary anchorage would be unnecessary.

With the forms securely anchored, concreting got underway. Each 94′ 6″ section of gravity wall entailed the placement of approximately 2,100 cubic yards of tremie concrete to elevation +2.0.

Since only 2 sets of forms had the end closure panels, the third form was set and ready to receive the closure panel as soon as it was stripped from previously placed and set monolith.

The extensive fleet of floating equipment placed on the job by Merritt-Chapman & Scott included the following:

One 75 Ton Floating Whirley Derrick.
Two 50 Ton Floating Whirley Derricks.
One Floating Concrete Plant.
One Floating Pile Driver.
One Stiff Leg Floating "A" Frame Derrick.
Two Truck Land Cranes.
One Cats Driven Crane.

And numerous smaller pieces of equipment.

Concrete was batched aboard a floating concrete plant with 110 c. y. capacity per hour. Concrete for the gravity wall was placed through four tremie pipes at an average of 50 yards per hour. Stone, sand and cement was delivered to the job site aboard barges. Fly ash was received on freight cars in L. C. L. containers.

Once the tremie concrete had been placed in the three 94′ 6″ forms, a seven-foot lift was added in the dry, carrying the wall to elevation +9.3. After allowing the concrete to set for 3 days, forms were stripped preparatory to installing two of them for the two intermediate monoliths. While forms were being stripped, the anchorage system for the first two sections was removed and repositioned to handle the intermediate pours.

It might be noted at this point that the creosoted timber lagging that sheaths the outboard face of the gravity wall from elevation —2 to +9.3 were built into the forms during their construction, and left affixed to the concrete when forms were stripped.

It was general practice to build five adjoining monoliths at a time since their total length approximated one berth. As berths were successively turned over to the contractor, he repeated this process of dredging, sanding, pile driving, placement of forms and concreting. He consequently was frequently moving from one end of the pier to the other.

Construction of the 27-foot deck, slab, with 17′ 2″ cantilever, was started following completion of the gravity wall sections. The cantilever slab tapered from 4′ to 1′ 6″ in depth. The inboard end of the new deck slab abutted the deck of the existing pier.

An underwater footing for forms used in construction of the cantilever slab was provided during erection of the gravity wall. This was achieved by boxing out the gravity wall form at elevation —2 so as to create pockets to receive the struts supporting the cantilever forms.

Frames for the cantilever forms were fashioned from light channels and angles in approximately the shape of a number 7, with a supporting diagonal strut. These frames were individually set at 3′ centers, with the lower end of the struts resting in the prepared pockets previously cast in the outer face of the gravity wall. The top section of the frame was anchored by tie rods embedded in the previously poured concrete of the gravity wall.

The top members of the frame were sheathed with two-inch timber lagging, which, after serving as the bottom form for placement of concrete, was left in place to protect the undersurface of the slab.

Creosoted sheathing served as the outboard form for the vertical portion of the gravity wall, and was left in place when forms were stripped. Spikes nailed to the inboard side of the sheathing acted as anchorage for the lagging.

The cantilever slab was cast in 31′ 6″ sections. All told, approximately 130 frames were purchased and used in assembling 13 sections of forms. The 31′ 6″ sections were cast in alternate monoliths.

Before concreting, reinforcing steel was placed and secured. Cantilever slab forms were boxed out for utility manholes and bollards. As a final step, provision also was made to box out depressions in the cantilever slab for a set of gantry rails and a set of standard gauge railroad track. This was done by suspending steel forms from a strongback placed transversely over the form. Anchor bolts for the gantry and railroad rail were secured to forms and cast in concrete slab. These forms were securely chocked against the strongback to prevent uplift during placement of concrete. Forms were stripped after compressive strength of concrete reached 2,000 lbs. per sq. inch.

After construction of the cantilever slab, a fender system comprised of a double row of timber piling was placed. Piles were driven on 10′ 6″ centers, their tops resting against a rubber block secured to the inboard face of the inner pile. The lower chocks are set at Elevation +2.5.

After placement of the gantry and standard gauge railroad tracks, the deck of the cantilever slab was covered with a 2″ surface of bituminous paving.

A comparatively minor, but most interesting phase of the contractor's work on the Boston Army Project involved reconstruction of its two gantry cranes. Prior to rehabilitation of the pier, their two outboard legs rode on a rail atop the existing deck. The inboard edge of the crane rode on a rail framed into the side of the pier shed above the deck.

Transfer of the gantries to their new location atop or new deck required construction of a new set of inboard legs. As you can readily gather from the foregoing, there were comparatively few unique construction aspects to rehabilitation of the Boston Army Base Pier, beyond the basic conception and design of the gravity wall and cantilever slab forms. However, the contractor's problems were complicated by the requirement to schedule the rehabilitation berth by berth, as they became available. The project could have been expedited considerably had the contractor been able to carry out each operation in a continuous, uninterrupted cycle. This would have required occupation of more than the two berths permitted at one time. The expeditious manner in which this project has been executed in the face of these difficulties is a tribute to the cooperation of all four parties involved: the owner, the operators of the pier, the consulting engineer, and the contractor. On behalf of Merritt-Chapman & Scott, we want to take this opportunity to express the contractor's thanks for the cooperation shown throughout by the U. S. Army Corps of Engineers, as the owners, Tidewater Terminal as the operators, and by Fay, Spofford and Thorndike, as the consulting engineer.