CONSTRUCTION OF DRY DOCK NUMBER 6, PUGET SOUND NAVAL SHIPYARD

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My contacts with this dry dock started in a very small way back in 1947 at which time the Puget Sound Naval Shipyard had the first indications that they would need to expand their dry dock facilities. Preliminary work was started at that time and continued with increasing intensity as the necessity for increasing the dry dock capacity became more acute. Finally, with the addition of the Forrestal Class carriers to the fleet it became very obvious that a dry dock was necessary to maintain them and the Puget Sound Naval Shipyard was selected as the site of this important Facility to serve the backbone of the fleet. I think a look at the world map would show an obvious need for a dry dock in the strategic North Pacific area. With no facilities on the Pacific Coast for docking a badly damaged Forrestal carrier, it would have been necessary for it to go 15,000 miles to the East Coast since it could not go through the Panama Canal. Concurrent with the decision to locate the dry dock at the Shipyard was the decision as to where would be the best place in the shipyard to locate it. Mr. Mueser has given you a description of the underlying geology and after many borings and conferences the present location was decided upon as offering the maximum advantage of economical construction while providing the shipyard with a much needed additional 13½ acres of land.

At first blush, the decision to locate the dry dock in open water appears rather startling but there was no sound engineering reason that rendered this decision infeasible.

I was not a partner in the early stages of the design of the dry dock. I left the shipyard in 1948 to return in 1957 at which time the dry dock was in the final design phase. I must confess that I oftentimes was confused with the many design problems that confronted me upon my reporting.

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Dry Dock Number 6 is considered the world's largest. There are one or two that are wider and one or two that may be longer but I know of none that are deeper. From the standpoint of volume, this is clearly the world's largest.

Waterfront structures frequently have a habit of becoming construction problems and right from the start the Bureau of Yards and Docks, who had the responsibility for constructing this dock, recognized that this dock could not be "business as usual." I think the first evidence of this was when the officer in charge of the design contract, Captain Zola, also District Public Works Officer for the 13th Naval District, recognized the fact that the shipyard was the customer and that for this important facility, to include as many of the desired features as possible it would be necessary for the shipyard to be a partner in the design.

For this reason, the Public Works Officer of the shipyard ran the design conferences with the architect-engineer, Moran, Proctor, Mueser & Rutledge and Carey & Kramer. The shipyard engineers had been living with these problems for so many years that they had worked out their requirements and it was only by their intimate association with the architect-engineer that these requirements could be factored into the design.

Another decision by the officer in charge was that we would have a pre-advertising conference. This conference was held about three or four weeks before advertising the contract. It was attended by 175 contractors and material suppliers from all over the country. The shipyard acted as host in order that everyone could see and evaluate the construction site. A briefing lasting one hour and five minutes complete with about 40 slides covered every aspect of the construction. The briefing had in mind two major objectives. The first was to inform prospective bidders as to the scope and magnitude of the work so that by proper evaluation of its magnitude, contractors could determine the best organization that would be required to handle the job.

The second one, while not voiced openly, was to indicate to marginal contractors and small contractors not familiar with the hazards of major waterfront contracts the magnitude and difficulties of the construction so that we would not have the problem of rejecting bids by unqualified contractors. The pre-advertising conference took a great deal of effort but it was considered as being worthwhile.

One contractor stated that the briefing had saved him at least two weeks of studying blueprints in order to understand the scope of the work.

Another indication that the Navy did not consider this project in the "business as usual" category was the early decision that we would depart from our usual procedure of leaving construction procedures up to the contractor. Past experience with major waterfront structures and particularly with dry docks has indicated that contractors frequently do not know the sequence of construction events that the designers had in mind. Disastrous results can and have occurred when a contractor does something out of sequence planned by the designers. Consequently, we directed in our specifications the sequence of events that we expected the contractor to follow and even designed the cofferdam. Admittedly, the Government took responsibility in doing this but we felt that the end justified the means. There were four major phases that the contractor had to follow. He was allowed considerable freedom within the four phases but each phase had to follow the other.

Lastly, the decision was made to make the Architect-Engineer a partner during the construction phase. On most government jobs the architect-engineer does not continue into the construction phase except possibly to check shop drawings. To this end, a supplemental contract was entered into with Moran, Proctor, Mueser & Rutledge and Carey and Kramer to provide a resident engineer as adviser to the Resident Officer in Charge of Construction. This man proved invaluable to me. He was that rare combination of a good design man and a good construction man. In addition, although he was on the shady side of 55, he was in such good physical condition that he could make underwater dives to determine the suitability of the foundation clean up prior to the deposition of our selected fill. The confidence that we could place in having a qualified engineer make these inspections greatly simplified the decision-making process because obviously we did not have to rely on the reports of a diver who was not quite sure what he was looking for.

Bids were opened on 17th of December 1958 after a 105-day advertising period. There were 9 bids received ranging from $21,645,000 to $24,990,000 with the second low bidder only $244,000 higher than the low bid. This relatively narrow range speaks well for the quality of the plans and specifications prepared by the design contractor. The completion time was set forth in the specifications at 1065 days and to date there have been 124 days of extension granted which will bring the completion into late March 1962.

The contractor started demolition work on 8 January 1959 and shortly thereafter moved in a 16-inch hydraulic dredge. This dredge, even though it had had the ladder extended, could only dredge to a depth of about 65 feet below the surface. All dredging below that was by clam bucket. One of our first problems which demonstrated the necessity of not taking anything for granted was an unanticipated clay pocket.

There had been several cruisers of the Pacific Reserve Fleet alongside the pier and in the subsurface investigations it had been considered impractical to move these ships in order to ascertain the bottom conditions under them. Drilling on both sides of the ships showed that the ground should have been continuous but almost immediately we discovered that in that particular location we had about 3,000 cubic yards of overdredging.

The next major problem came when we uncovered the hard clay layer in the center of the dry dock. Preliminary borings indicated that this material would make a suitable foundation but upon exposure to water it turned to soft clay and it was necessary to remove this layer. There was about 70,000 cubic yards of overdredging involved in this pocket and since the hydraulic dredge had left the site it was necessary to clam all of this material out of the bottom.

A diver's inspection of the bottom just prior to depositing the selected fill showed that despite all efforts there still was a 6″ to 30″ layer of soft semi-liquid clay that could not be removed. We were afraid this would create a plane of weakness. To overcome this problem it was necessary to place a three-foot blanket of coarse gravel from about one-inch to 3-inch diameter. This gravel penetrated the layer and keyed the fill into the basic glacial till support. Subsequent borings proved that this had been accomplished

A derrick barge was used to clam material from the dredging area. All in all there was about 625,000 cubic yards of material that was removed before we could replace it with suitable foundation material. About 125,000 cubic yards was removed by clamming and the balance of 500,000 cubic yards by hydraulic dredge.

The contractor was fortunate in locating foundation material less than three miles from the contract site. The pit was about

1500 feet in diameter and 75-80 feet deep. All together there were about 1,500,000 cubic yards of material removed from this pit. The material from the pit was barged to the site and hydraulic monitors sluiced the fill off the barge. Bottom dump barges were allowed in certain locations but were prohibited by the specifications adjacent to the cut-off walls.

When the free water had been removed, large quantities of soupy mud in thicknesses from 6 to 10 feet deep were found in the center of the site. This was believed to be caused by the slow settlement of the fine silt particles during the fill operation. This material was bulldozed to collection points where most of it was trucked out of the site.

Under water the fill material held a natural slope of 1 on 2 and ¾ while in the dry a slope of 1 on 1 and ¾ could be maintained. The excess material had to be removed in order to work the site. Approximately 400 well points placed on 10 feet centers were the prime means of keeping the construction site dry. A conveyor belt was used to remove and stockpile a good deal of the material and this saved the contractor a great deal of time and effort in moving the extra material from the site. This material was later used for backfill between the walls and the construction dams.

The outboard end of the dry dock was all supported on fill. When the time came to place the concrete floor it was apparent that the fill had not consolidated sufficiently to be assured that no further consolidation would take place. For this reason, it was determined that is was necessary to artificially consolidate the material in order to avoid any settlement of the dock after construction. After considerable discussion the vibro-flotation method was decided upon. The method proved quite successful. The effect of the vibration and additional material was felt up to a radius of about 8 feet. The holes were compacted to varying depths from 8 to 23 feet deep. All in all a total of 824 holes were compacted. There was about 6 cubic feet of material added for each lineal foot of each vibrated hole. It was estimated that the vibro-flotation operation increased the relative density of the fill material by 20-30%.

Drainage tile were imbedded in the drainage course which is immediately under the floor slab to assure that there be no hydraulic uplift on this type of dock. A concrete working mat four inches thick was placed over the drainage course. In order to assure that there would be no filling of the interstices of the drainage mat, a polyethylene sheet was laid on top. The working mat was reinforced by 6 x 6 x 6 wire fabric.

The first structural concrete was poured on 7 July 1960, just shortly before I left the job. Each block of the concrete slab was 24 x 40 x 7 feet thick and contained 250 cubic yards of concrete and 16 tons of reinforcing steel.

The contractor elected to set up a batching plant about 600 feet from the dry dock site. The shipyard made available to him a pier alongside which he brought his materials and delivered them directly to the hoppers of the batching plant. The batching plant consisted of two, two-cubic-yard Koehring mixers. The plant had a theoretical capacity of about 1,000 cubic yards a day. Electronic control and recording devices were required.

Flooding is accomplished by gravity through a culvert incorporated in each of the dock side walls through the entrance abutments and terminating in a transverse culvert just inboard of the inner caisson seat.

Three of the four main dewatering pumps take their suction from the dry dock floor through a shallow intake well. Large steel gratings will cover the well when completed. Temporary steel struts were used to support the pumpwell side walls. As the concrete was raised the steel struts were removed.

The contractor used the temporary false work required to drive the sheet piling cut-off wall at the head end of the dry dock to support a roadway between the East and West sides of the dry dock.

As excavation of the native material adjacent to the headend cofferdam progressed, additional temporary shoring was required.

Moveable gantrys were used to support the concrete wall forms. After aligning and bracing, concrete was placed from a concrete bucket through an elephant trunk in the wall forms. A total of 40,000 cubic yards of concrete were used in the dock walls.

After completion of concrete placement, the gantry is moved and the concrete forms were loosened 12 to 24 hours after completion of concrete placement. Concrete forms on the wall sections were removed 24 hours after concrete placement was finished. Intermediate concrete wall pouring proceeded in the same manner as described for the primary blocks.

Once begun, work progressed rapidly on the construction of the dry dock walls. Specifications required a 7-day curing period between the placement of adjacent blocks so the walls progressed in a checkerboard fashion. The inboard face of the wall is battered out for the bottom 24 feet and straight for the upper 24 feet. The outboard face slopes in from bottom to top.

TABLE I

SUMMARY OF MATERIAL QUANTITIES (ESTIMATED)
DRY DOCK NO. 6

MATERIAL			UNIT	QUANTITY
DREDGING				
TOTAL			CY	550,000
FILL & BACKFILL				
INITIAL FILL			CY	451,000
BERM FILL			CY	515,000
COFFERDAM FILL			CY	90,500
BACKFILL	CY	352,000		
- SPILLOVER	CY	153,000		
- EXCAVATION	CY	100,000		
- FROM C'DAM	CY	45,250	CY	53,750
TOTAL			CY	1,110,250
SHEET PILE				
BERM			TONS	3,050
COFFERDAM			TONS	2,390
TOTAL			TONS	5,440
CONCRETE				
DRY DOCK			CY	151,000
PIER 9			CY	900
SUBSTATION #83			CY	1,100
FLOODLIGHT TOWERS			CY	255
TOTAL			CY	153,255
PRESTRESSED CONCRETE PILE				
TOTAL			LF	12,700

MATERIAL	UNIT	QUANTITY
REINFORCING STEEL		
DRY DOCK	TONS	8,300
PIER 9	TONS	115
SUBSTATION #83	TONS	80
FLOODLIGHT TOWERS	TONS	15
TOTAL	TONS	8,510
MISC. IRON & STRUCT. STEEL		
DRY DOCK	TONS	360
RAILS & RAIL PLATES	TONS	320
SWITCHES & FROGS	TONS	70
SERVICE BUILDING	TONS	35
FLOODLIGHT TOWERS	TONS	81
TOTAL	TONS	866
RIP RAP		
TOTAL	CY	8,400
DRAINAGE COURSE		
TOTAL	CY	92,000
BITUMINOUS CONCRETE PAVEMENT		
TOTAL	SY	32,500
CONCRETE MASONRY		
TOTAL	SF	4,400

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Table I is a summary of the estimated material quantities. This was prepared prior to the construction and the quantities have changed slightly. For example, the total amount of dredging was about 625,000 cubic yards instead of the 550,000 shown here. There was also an increase in the backfill to about 1,200,000 cubic yards but the other quantities are substantially as shown.