

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

BY ROBERT J. BASSO*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Structural Section, B.S.C.E., held on January 23, 1957.)

IN ORDER to present a clear picture and understanding of the work now under construction of the Boston Army Base, it is advisable to give some of the leading facts of the matter and the background leading up to the present construction.

ORIGINAL CONSTRUCTION

Construction of the Army Base was completed during the latter part of 1918, on what was originally tidal flats. The construction, which cost in the vicinity of \$22,000,000 at that time, included a 2-story steel frame Wharf Shed 135 feet wide by 1,638 feet long, 2-3-story reinforced concrete frame pier sheds 100 feet wide by 924 feet long, an 8-story reinforced concrete storehouse 126 feet wide by 1,638 feet long, an Administration building, Boiler House, Substation and several other smaller buildings, and included wharves and piers for docking ships in 10 berths.

Prior to the 1917-1918 construction, a portion of the Army Base property was filled representing approximately one half the present area. During the 1917-1918 construction, a finger of solid fill extending out into the harbor and retained by a concrete sheet pile bulkhead was built. This latter area is that on which the pier sheds now stand.

The 8-story Storehouse, the Administration Building, Boiler House, Substation and the several other smaller buildings were founded on concrete caissons or concrete piles. The Wharf Shed, the easterly end of the Pier Sheds, and the wharf and pier aprons which form the entire perimeter of the Army Base are supported by untreated timber piles driven into soft and medium blue clay, with the ground line at the piles varying from low water to about 30 feet below low

*Project Engineer, Corps of Engineers, U. S. Army, New England Division.

water. The range of tide at the Army Base is about 9.5 feet. The elevation of the wharf and pier aprons is 18 feet above low water.

WHARF AND PIER STRUCTURES

The wharf and pier structures have offered the greatest problems over the period of years. The structural components of these structures consist of very lightly reinforced pile cap walls extending transversely across the structures and supported on rows of the timber piles. On these walls are carried the heavily reinforced longitudinal crane and railroad track beams and the deck slab which spans from wall to wall. The purpose of the pile cap walls was to permit cutting off the timber piles at an elevation below high tide to keep them permanently wet, with the walls acting as a continuation to support the deck structures.

DAMAGES TO WOOD PILES

At the time the wood piles were driven, marine borer activity in Boston Harbor had been at a very low level for a number of years. However, in 1925, the crustacean borer, *Limnoria*, again became active in considerable numbers. By the early 1930's, the wood piles had been damaged to a great extent. The severity of the attack increased steadily and a detailed inspection in 1933 revealed that the average cross-sectional area at the low water line was about 66% of the original area of the piles, and it became necessary to make repairs and prevent further damage to the piles by the marine borers.

REPAIRING DAMAGED PILES AND NEW PROTECTION INSTALLED

As a result of a study made at that time, it was determined to surround the entire perimeter of the structures supported on wood piles by a steel sheet pile bulkhead and to fill the inclosed area with sand.

This work was accomplished as a PWA project in 1935 under supervision of the Constructing Quartermaster at a cost of \$976,000. A total of about 750 wood piles were replaced by driving through holes cut in the concrete deck, and a great many more were repaired by encasing the damaged portion with concrete. The area was, at this same time, inclosed by a steel sheet pile bulkhead extending over 5,600 feet around the perimeter of the wharves and piers, and filled with about 290,000 cubic feet of sand, hydraulically placed. The top of the steel bulkhead was anchored to the pile cap walls of the wharf aprons and sheds.

In order to reduce the water pressure behind the bulkhead, drainage slots 1 inch in width by 24 inches high were cut in the webs of the piling sections. The bottom of the slots was at an elevation of 2 feet above mean low water, and each slot was backfilled in its immediate vicinity with sand and gravel intended to serve as a filter.

Within a short time following placement of the sand fill behind the bulkhead, small outward movements of the wharf and wharfsheds were detected in certain sections. In 1937, to prevent further movement of the structures, a system of anchors was installed. Each anchor consisted of a mass of concrete buried in Terminal Street with a tie rod imbedded in the mass concrete and attached to the concrete pile cap walls.

DAMAGE TO WOOD PILES RE-OCCURS

By 1944, the sand fill behind portions of the bulkhead had been washed out through the drainage slots to a depth of 4 to 5 feet, and the wood piles were again severely damaged by new limnoria attacks and in 1945-1946 a drainage system was installed behind the bulkhead; the drainage slots previously cut were closed with welded steel plates, the most severely damaged piles were repaired by incasement in concrete and the lost sand fill was replaced.

FIRST DISCOVERY OF DAMAGE TO STEEL SHEET PILE BULKHEAD

In March of 1953, it was discovered that holes in the steel sheet piling were occurring at and just below the low water line and that the sand fill was being washed out leaving the wood piles once more open to attack by the marine borers. In many cases where holes had not yet occurred, the thickness of the metal had been reduced to the extent that a sharp blow with a boat hook penetrated the piling. Further, the loss of cross-sectional area of the sheet piling was placing the structure in an unsafe condition, and necessity for major reconstruction was becoming evident.

POSSIBLE CAUSES OF LOSS OF METAL

The problem of the corrosion of steel members in salt water has been and still is the subject of considerable study, with widely different theoretical explanations being given for what happens.

The first thought after discovery of the corrosion taking place was the possibility of loss of metal through electrolysis caused by stray currents from sources of direct current electric lines in the vicinity.

Therefore, two sets of recording chart readings were made for a period of 24 hours. However, both tests showed the salt water to be positive to the steel piling in the order of about 1 millivolt which indicated that deterioration of the steel piling could not be from stray currents.

Dr. A. P. Richards of Clapp Laboratories submitted a statement based on investigations and conferences with other scientists interested in the causes of and protection against corrosion in sea water. In part, Dr. Richards' statement is as follows: Quote—

“A number of theories have been advanced to explain the accelerated corrosion at the low water level, which is the problem in this case. One states that this is due to a marked reduction in aeration cell. The area affected by oxygen being the cathode or potential zone. It is stated that during a falling tide, the steel in the air becomes passivated. When the tide turns and the steel is again wet, the newly wet sections become active. The lowest area, of course, has less total exposure to oxygen, resulting in accelerated corrosion.”

INVESTIGATIONS AND RESULTS

Faced with this latest development of corrosion, the New England Division office of the Corps of Engineers was directed to make a thorough investigation of the condition of the waterfront structures and to report on the findings of these investigations together with recommendations for repairs and the estimated costs thereof.

The firm of Fay, Spofford & Thorndike was engaged to make the investigations and prepare the report and to present various schemes from which one would be selected.

In December of 1953, the investigation had been completed, and a report was presented which indicated that corrosion in the bulkhead had progressed rapidly since the first discovery earlier in the year and that about 10 percent of the sheet piles had holes in them at low water line indicating that, because of the rapid rate of the corrosion, if corrective measures were not taken a failure of the bulkhead must occur, and that such a failure was likely to occur suddenly with disastrous effects on the wharf structures and possibly to the Wharf Shed. There appeared to be no practical stop-gap method of arresting the corrosion and providing a satisfactory safety factor to the structure.

ABANDONMENT OF THE WATERFRONT STRUCTURES

Since the close of the last war, the waterfront structures were being leased to private interests and were not considered necessary for

immediate Government use. Some thought was being given to complete abandonment of the structure. However, in view of the failure which would occur, with the possibility of portions of structures falling out into the adjacent waterway, it was determined that if the facilities were abandoned, some means of protection against collapse, or removal must be provided. It was estimated that temporary protection, which would provide satisfactory safety measures for about 10 years, would cost approximately \$1,400,000. To remove the structures, with the exception of the major portion of the pier Sheds, would cost approximately \$4,300,000. In both cases, all possibilities of shipping would be eliminated.

MOVE TO SAVE THE ARMY BASE

Faced with the loss of Boston's greatest shipping facilities, the Port of Boston Commission, together with other local interests, held a meeting in Washington with Government officials in an effort to prevent this great loss. Considering the cost involved to abandon the structures, which the Government would have to expend, together with the inability to use the Army Base as a shipping port in the event of a national emergency, Congress passed an act authorizing the Department of the Army to rehabilitate the wharf and pier structure at a cost not to exceed \$11,000,000 and to lease those facilities to the Commonwealth of Massachusetts. However, as a condition to the execution and delivery of such lease, the Commonwealth is to pay 10 percent of the total cost of rehabilitation. Further, the lease provides that during any national emergency, or declaration of war, if the Department of the Army determines that the leased property is necessary for military purposes, the United States shall have the right to re-enter such property for such period of time determined to be necessary in the interests of national security.

BASIS OF METHOD OF REPAIRS

The report of December 1953 by Fay, Spofford & Thorndike based on field investigations contained four recommended schemes and estimated cost of each for rehabilitation of the wharf and pier structure. After evaluation of each scheme by various departments of the Army, a final one was selected. In July 1954, the New England Division office negotiated with Fay, Spofford & Thorndike for designs, plans and specifications which were completed in April 1955, issued for bids and finally awarded for construction in June 1955.