REINFORCED CONCRETE DOCK CONSTRUCTION.

THE study of reinforced concrete docks involves so many phases of the problem that they are difficult to cover with any degree of completeness in a single article. There are many in successful operation in Europe, the most extensive development being in England, where they have, to a certain extent, proven their practicability and commercial economy. But in America they are more or less of a novelty, and can hardly be said to have, as yet, proven themselves. For this reason there is much of interest in a review of the art of reinforced concrete dock construction given by Harrison S. Taft in a paper on May 20, 1914, before the American Society of Civil Engineers—particularly in that portion of the paper outlining the practice in the old world and examining the work in each country. Their successful use for about 50 years in Europe for structures exposed to the action of salt water leads one to the conclusion that what has been done there, and in other parts of the world, will bear investigation. We extract the following pertaining exclusively to English practice, from Mr. Taft's paper:

In building reinforced concrete docks and other concrete structures in sea or fresh water, it is only natural that a forested country should be the last to take up the development of such a material. Consequently, America has been far in the rear in regard to this question, as compared with what other and older countries have accomplished. In England, France, Germany, Italy, and other European countries, in Australia, and in Asia, as well as in certain South American countries, concrete seawalls, breakwaters, dry docks, piers, trestles, coaling stations, etc., in salt water, have been in existence for years.

Southampton, Eng.—One of the most noted developments in reinforced concrete construction, as applied to harbor and dock development, is that of the London and Southwestern Railway Terminals at Southampton. The first and most prominent reinforced concrete structure in connection with this terminal was a coal barge jetty, 300 ft. long and 20 ft. wide, built in 1904, on the Hennebique system of driven concrete piles. The piles are about 44 ft. long, standing in 29 ft. of water at high tide, the rise and fall of the tide being about 13 ft. Each pile carries a maximum load of 17 tons.

This structure carries a very heavy traveling coal-hoisting apparatus for unloading coal from large vessels docked on one side, into harbor barges or scows which lie on the other side. Thus the jetty is subjected to constant blows from both sides, in addition to the heavy vibration due to the traveling machinery it supports.

In speaking of this jetty, Mr. Francis Wentworth-Shields, Dock Engineer for the London and Southwestern Railroad, says:

"Though the impacts from the vessels and scows cause this whole jetty to sway, there seem to have been no signs at the end of the first 2½ years of its existence of any of the concrete peeling off."

During recent years this dock or jetty is said to have shown some signs of deterioration, due to the vibration of the heavy machinery traveling along it, the supposition being that it was built too light in the first place to absorb the heavy vibrations to which it has been subjected. Still, the dock is said to have considerable elasticity. In one instance it was in heavy collision with a steamer, two piles and the beams they carried being broken. The dock was effectively repaired, but perhaps with some difficulty, though it is claimed that the repairs were easily accomplished.

The same railroad company has built several other reinforced concrete pile docks at Southampton, designed to carry the same heavy deck loads as the coaling jetty, but without the heavy vibration to which this jetty is subjected. Though built on the same system of construction as the coal jetty, the latter docks have shown no signs of wear or deterioration. It is said, on the best of authority, that they have cost nothing to date for maintenance.

The largest of these is the extension, on the Itchen Front, of "The Empress Dock," a widening of the so-called "Old Extension Quay" by a reinforced concrete pile structure, 50 ft. wide and about 1,300 ft. long, parallel to and securely dovetailed into the old quay wall. This widening dock is built of complete concrete bents, along the tops of which are steel deck-beams or stringers, which in turn are covered with 4 in. of wood, a wooden block pavement being used for the wearing surface. The depth of water at low tide at the face of this structure is 35 ft., which, with a 13-ft. rise and fall of the tide, gives a depth of 48 ft. at high tide.

One of the finest cold storage and cattle stations in existence was built at Southampton in 1905 to accommodate the foreign cattle trade. The landing stage or jetty of this station is a reinforced concrete structure, 200 ft. long and 38 ft. wide, connected with the main land by two runways, 142 ft. long and 15 ft. wide.

On the opposite side of Southampton Harbor, at Woolston, on the Itchen, there is a reinforced concrete landing dock, 136 ft. long and 100 ft. wide, built in 1899 on the Hennebique system. This was the pioneer of reinforced concrete dock construction in Southampton waters. Up to date, this dock has cost practically nothing for repairs, except for damages due to the fact that it was rammed or otherwise damaged by a large steamer; it is in excellent condition at present. The cost of making the repairs is said to have been very small.

Up to the present time, it appears that at least six reinforced concrete docks, jetties, or quays, have been built in Southampton waters.

In building one of the Southampton docks, it is stated that some of the concrete piles were sprung out of line in drying them. A prominent American engineer reports that he saw a number of piles from 1 to 2 ft. out of line, but that they showed no signs of cracks. It has been stated that, in handling Chenoweth concrete piles, up to a length of 61 ft., and 13 in. in diameter, they were rolled about like wooden piles, at times having quite a spring in them. Under this treatment they showed a remarkable degree of elasticity and no signs of cracking.

Bending of Piles.—In discussing the bending of concrete piles, it is of interest to note a series of tests made on a hollow telephone pole in Fulham, London, England, in 1911. The pole was 44½ ft. long, 17 by 17 in. at its base (outside dimensions), tapering to 8 by 8 in. at its head. The thickness of the shell was 2 in., making the inside dimensions of the pole 13 by 13 in. at the base and 4 by 4 in. at the top. The vertical reinforcement consisted of 248 3/16-in. rods of high-tension steel, the ultimate tensional stress being from 80,000 to 85,000 lb.; 56 rods were grouped at each corner, 6 rods being spaced evenly on each of the four sides of the pole. The area of the concrete at the base was 106 sq. in., and the area of the steel 6.85 sq. in., a ratio of 0.0445. In making the test, the pole was set in 5½ ft. of massed concrete, with the pulling rope attached to its upper end.

In Table I. is recorded the pull, in pounds, the deflection, and the permanent set after the loads had been released.