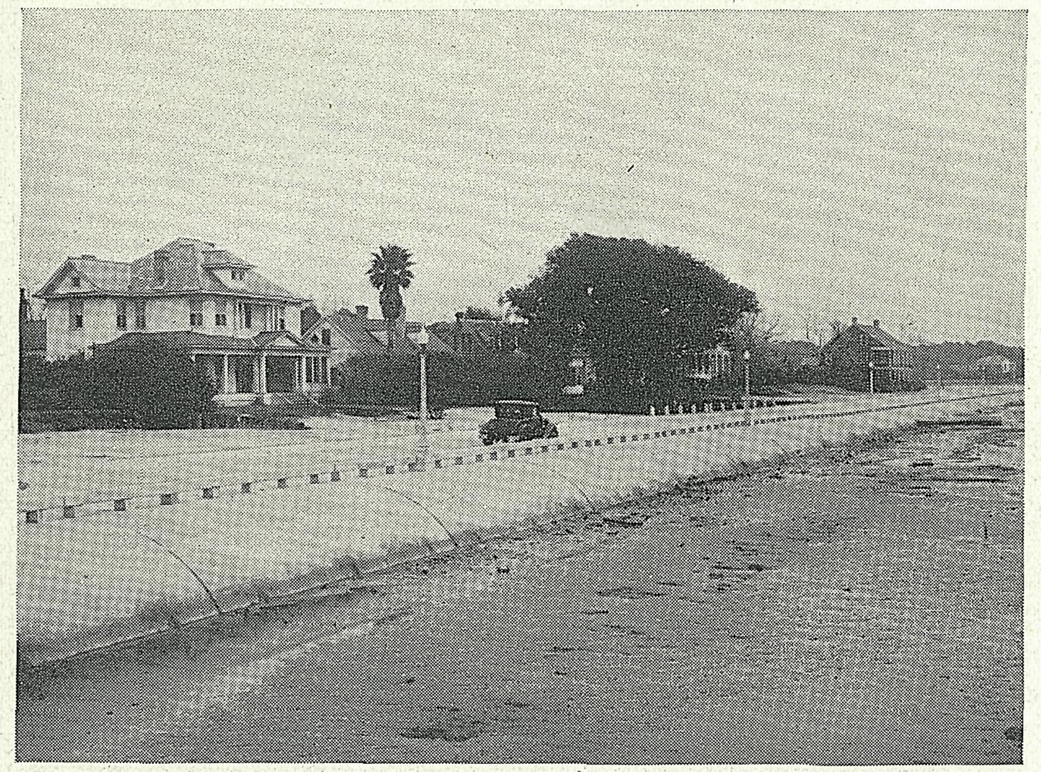


This unusual convex curved sea wall is located in Jackson County, Mississippi. The open curb permits drainage of the roadway. Designed and construction supervised by F. H. McGowen, C.E., Ocean Springs, Mississippi.

the strength and life of structures. However, under the practice of making the water-cement ratio a basis of the design of mixtures or the specification,* these factors become of importance principally through their effect on economy, for with a given water-cement paste the proportions and amount of aggregate to produce concrete having the workability suitable for the job will depend on these characteristics of the aggregates.

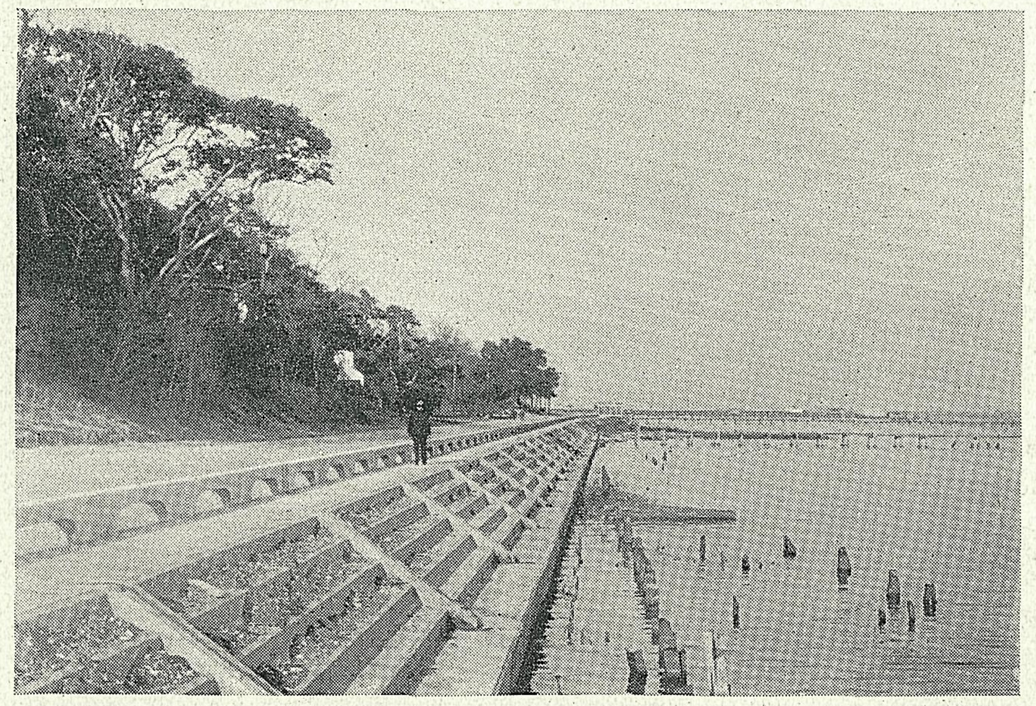
Designing Mixtures for Shore Protection Structures

The first step in selecting the water-cement ratio to be used in a shore protection structure is to make a careful analysis of the conditions of exposure to which the concrete will be subjected. Conditions that will affect the choice will include: Exposure to fresh or salt water; exposure to alternate wetting and drying in the warmer climates, and freezing and thawing in colder locations; continued contact or submergence in fresh or salt water; degree of intensity of storm action, the pounding of heavy seas, or the scouring action of moving water.

After the degree of exposure is determined, a water-cement ratio should be selected which will insure the production of concrete of sufficient strength and watertightness to resist the forces existing in the particular location. A decision as to the water-cement ratio to use can best be based on a study of the performance of structures in service in connection with the available data on freezing and thawing, and permeability. A careful study of existing structures along the Atlantic seaboard and the shores of the Great Lakes has been made. While it has been impossible in many cases to determine the exact mixes, water-cement ratios, materials and other important factors in the construction, enough data have been collected to show definitely the value of careful observance of the fundamental principles of the water-cement ratio law. Many laboratory investigations have been made which also show the importance of this conclusion.

Recommended water-cement ratios for concrete to meet different degrees of exposure are shown in Table I. These ratios are intended to apply only when plastic and homogeneous mixtures are used, and when the portland cement meets the present standard specifications of the American Society for Testing Materials. They further assume a minimum curing equivalent to that obtained when the concrete is protected against loss of moisture for at least 10 days at a temperature of 70 degrees F. If strength requirements for a particular structure exceed those to be expected from the recommended water-cement ratios, the more severe requirement should govern. These recommended ratios should be safe, and yet not unduly conservative.

Under the modern method that acknowledges the value of the water-cement ratio principle, concrete for a shore protection structure is specified on the basis of proper workability and the ratio between water and cement.



This step type sea wall near Bay St. Louis in Hancock County, Mississippi, was completed in 1928. The openings in the curb permit the return of storm water to the Gulf.

*See Typical Specifications for Concrete Shore Protection Structures, page 28.

TABLE I

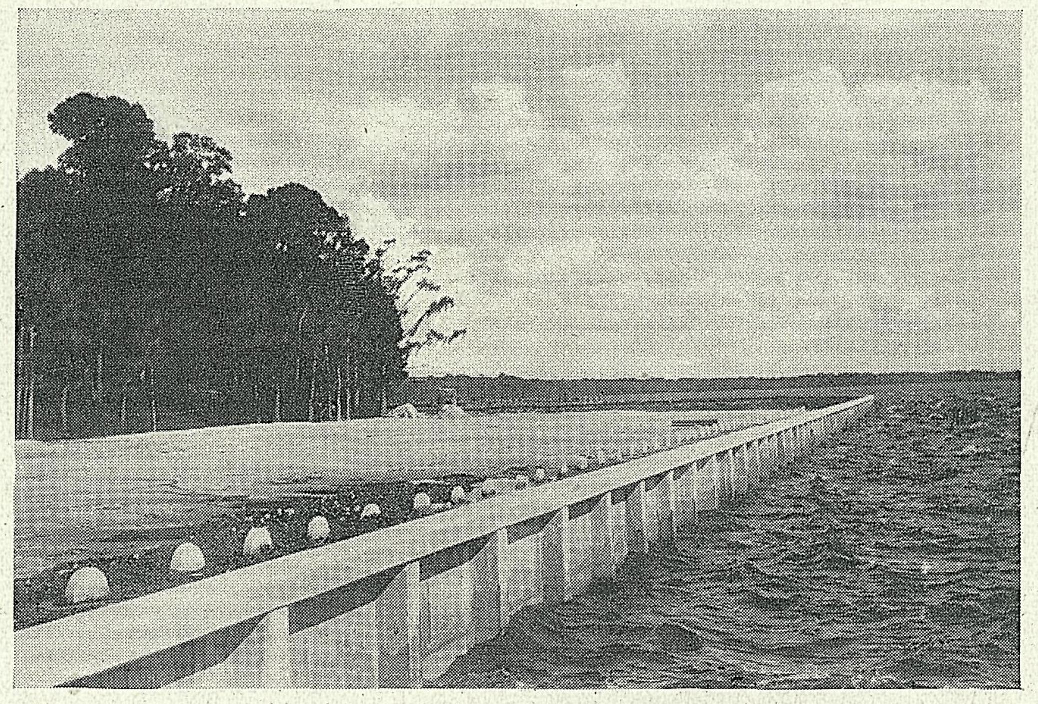
RECOMMENDED WATER-CEMENT RATIOS FOR CONCRETE SHORE PROTECTION STRUCTURES, TO MEET DIFFERENT DEGREES OF EXPOSURE

These are minimum requirements based on the use of workable mixtures of such consistency that the concrete will be placed without honeycombing. They are also based on the requirement that the structures will be adequately cured by being kept continually moist for a period of at least 10 days.

Exposure / Class of Structure	Water-Cement Ratio, U. S. Gallons Per Sack*			
	Precast sheet piles, bearing piles and all precast slabs used in sea walls, bulkheads and jetties.	Thin section bulkheads and light retaining walls. Thin reinforced linings placed on earth.	Moderate section breakwaters, sea walls, bulkheads and jetties. Reinforced concrete docks.	Heavy massive breakwaters, sea walls, bulkheads and jetties. Heavy foundations.
EXTREME				
1. In all locations where there is exposure to sea, acid and alkaline waters.				
2. In severe climates as of northern U. S., exposure to fresh water, alternate wetting and drying, freezing and thawing, as at the water line of walls and bulkheads on lakes and rivers.	5	5½	5½	6
SEVERE				
3. In moderate climates as of central U. S., exposure to alternate wetting and drying in fresh water as at the water line of walls and bulkheads.				
4. In severe climates like northern U. S., exposure to rain and snow and freezing and thawing, but not continuously in contact with water, as retaining walls set well back from the normal water lines of rivers and lakes.	5½	6	6	6¾
MODERATE				
5. In climates as of southern U. S., exposure to alternate wetting and drying in fresh water.	6	6¾	6¾	7½
6. Concrete completely submerged in fresh water but protected from freezing.				

*These quantities should not be exceeded even when resultant strength is higher than required for structural stability. Free water or moisture carried by the aggregate must be included as part of mixing water.

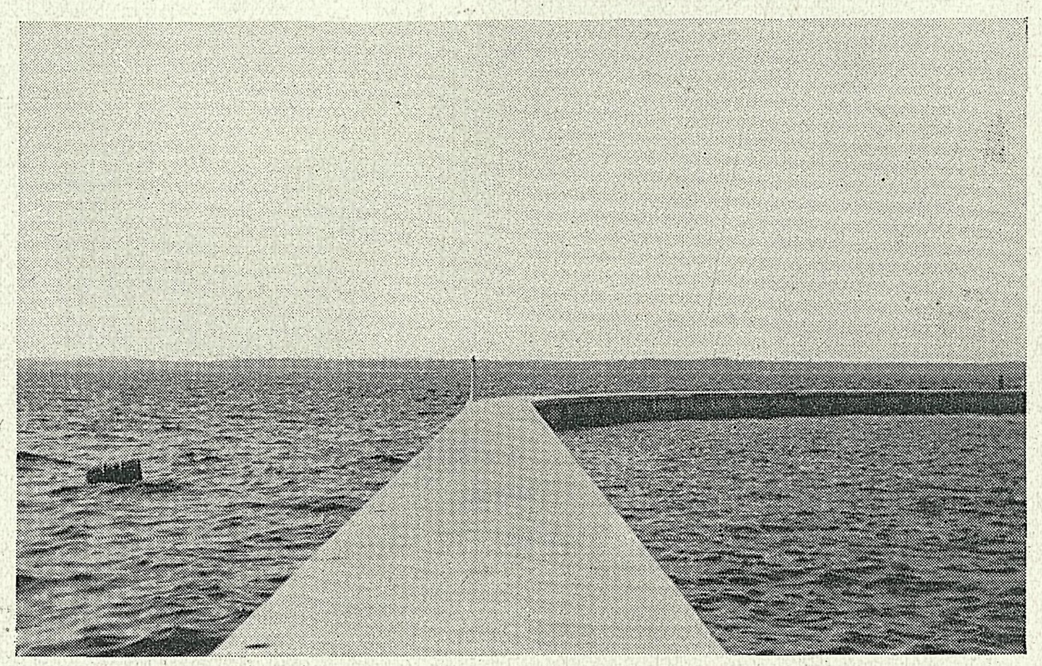
An example using a typical set of conditions may be taken to illustrate the method. A specification is desired for a counterfort retaining wall to be constructed well back from the normal water line of a river, in northern United States. The condition would be severe but not extreme. The wall will be exposed to rain and snow, and



A patented type of bulkhead consisting of precast slabs held by king piles. Protected steel tie rods anchor the wall to the back fill. This wall protects the estate of A. I. Du Pont, Epping Forest, Jacksonville, Florida. Designed and built by Shore-line Builders, Inc., Jacksonville.

freezing and thawing, but not continuously in contact with water. Referring to Table I of recommended water-cement ratios, it is found that 6 U. S. gallons per 94-pound sack of portland cement will be required, when at least 10 days curing at 70 degrees F. will be enforced. As the wall sections will not be unduly thin, a three to four-inch slump will be required. A six-gallon water-cement ratio under correct conditions will develop concrete having a compressive strength of 3,000 pounds per square inch at 28 days. This may be in excess of actual structural strength requirements, but in the interest of durability under these conditions of exposure, concrete of this quality will be required.

That portion of the specification which, under old conditions, would deal with mixture pro-



This patented type of construction consists of double concrete walls, sand filled, and capped with a reinforced concrete deck. Designed as a breakwater, this structure also forms a yacht basin for an estate near Jacksonville, Florida.