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Foundations for Large Bridges Across San Francisco Bay

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San Francisco Bay, an area of 463 square miles of water connected to the Pacific Ocean by a narrow gorge about one mile wide, has always presented a challenge to the civil engineer. Crossing the Bay and forming a part of the California highway system are four major bridge structures: the San Francisco-Oakland Bay Bridge, the Golden Gate Bridge, the Richmond-San Raphael Bridge and the Carquinez Bridge. The paper outlined the type of foundations used in the construction of these bridges.

The San Francisco-Oakland Bay Bridge, opened in 1936, has a length of about seven miles, including ramps and fills, and spans about $4\frac{1}{2}$ miles across the water. The methods of construction of pier foundations included the use of steel sheet pile cofferdams, Moran pneumatic caissons (*Ref. 1*) sunk in some cases to depths of 240 ft and open caissons (*Ref. 2*). The techniques of sinking the Moran pneumatic caissons were illustrated and discussed.

The Golden Gate Bridge, spanning across one mile of water, was completed in 1937.

The long suspension span of 4,200 ft resulted in only two piers being constructed under water. Difficulties encountered in the construction of an access trestle 1,100 ft long, a concrete fender wall and a pneumatic caisson, finally resulting in the use of the fender as a cofferdam for pier construction, were described (*Ref. 3*).

The Richmond-San Raphael Bridge, spanning four miles from Richmond to San Raphael, was completed in 1947. Of the 79 piers for the bridge, nine were built on land, eight were built in cofferdams in the shallow waters near the eastern bridge terminus and the remaining 62 were of the bell bottom type for which the contractor elected to use precast concrete structural units. The sequence of construction operations for the bell bottom type piers was reviewed and illustrated (*Refs. 4, 5*).

The most recently completed of the Bay bridges is the Carquinez Bridge, spanning 3,350 ft across the Bay and continuing to a total length of about 5,300 ft (*Refs. 6, 7*). The foundations for the Bay portion of the

bridge involved the construction of an anchorage abutment set in a shale and sandstone cliff at the north end of the bridge, three caisson piers founded on bedrock about 132 ft below the water line, a cofferdam type pier supported on 240 steel bearing piles and an anchorage pier 125 ft high located at the south end of the bridge. Caisson construction involved the novel use of relatively thin precast concrete slabs for the construction of caisson walls, thus decreasing the weight of the caisson and eliminating the need for outside forms.

It was hoped that the variety of techniques involving the use of long-established procedures, new ideas and the incorporation of modern developments which have been used for the construction of bridge foundations across San Francisco Bay would provide some idea of typical U. S. practice in the construction of foundations for large bridges.

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