

Chapter 38

THE STRUCTURAL BEHAVIOUR AND THE SHELTERING EFFICIENCY OF THE SUBMERGED BREAKWATER AT THE ENTRANCE TO THE PORT OF LEIXÕES MAINTENANCE CHARGES AND EFFECTS

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The urgent necessity for providing a system of protective works of the harbour of Leixões with complementary works to improve the poor conditions of the shelter in the basin and to protect ships entering the port became evident in 1934. In fact, the frequency of disaster to trawlers and to other ships within the basin during southwestern gales as well as the very dangerous conditions at the entrance under such gales were incompatible with the increasing economic importance of Oporto and its hinterland.

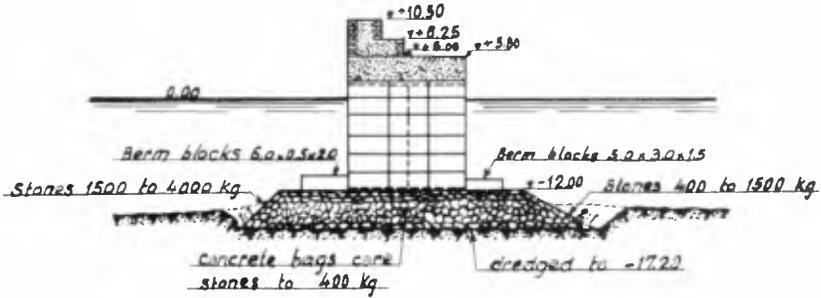
These bad conditions culminated in the foundering of the 9000 T Dutch steamship "Orania" at anchor in the basin colliding on the 19th December 1934 with the steamship "Luanda" when entering the harbour under severe hurricane.

The construction of the 1000 m long new breakwater was started with a 15 m wide vertical wall to be set partly on rocky bottom and partly on a sandy bottom. Before leaving the rocky bottom the upper part of the wall was destroyed by a strong gale (Fig. 1). For the advancement of the work the contractor and an official commission recommended the adoption of the Casablanca type of slope work.

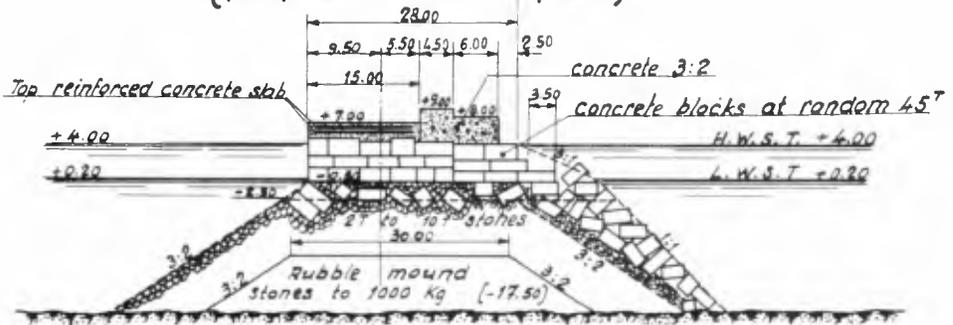
For economical reasons and on those of the sure possibility of its conversion into a conventional type of work, would it become convenient it was decided, at the author's suggestion, and after model study at Lausanne School of Engineer's Laboratory, to adopt a new type of submerged work, to replace the unsuccessful vertical type or the type of Casablanca proposed by the contractor (Fig. 2). The section adopted comprised a rubble mound core of stones to 1^m with the crest at level (-9^m00), and berms of rubble to 4^m, 12 m wide to the sea side and 10 m wide to the port side (Fig. 1).

The top and slopes of the mound were protected by an armour of 90^T concrete blocks with the corners cut for best accommodation. The cost of the work could be reduced to half of that corresponding to the last of these types of breakwaters and its maintenance charge greatly reduced. The estimated cost of the works would be reduced from £ 1.770.000 to £ 880.000 and the maintenance charges foreseen reduced from £ 35.400 yearly to £ 2.800 yearly (comparison with the Casablanca type).

HARBOUR OF LEIXÕES
BREAKWATER
 vertical type - (destroyed)
CROSS SECTION



TYPE OF CASABLANCA
 (proposed - not adopted)



CROSS SECTION AS EXECUTED

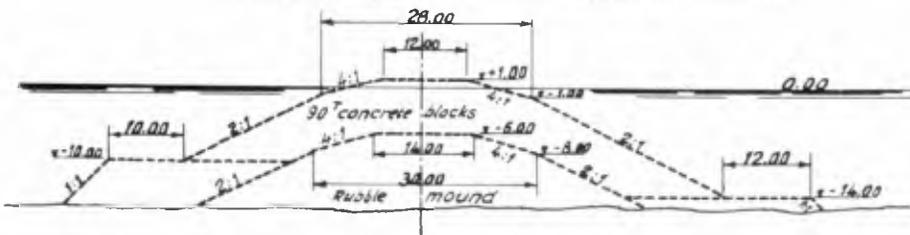
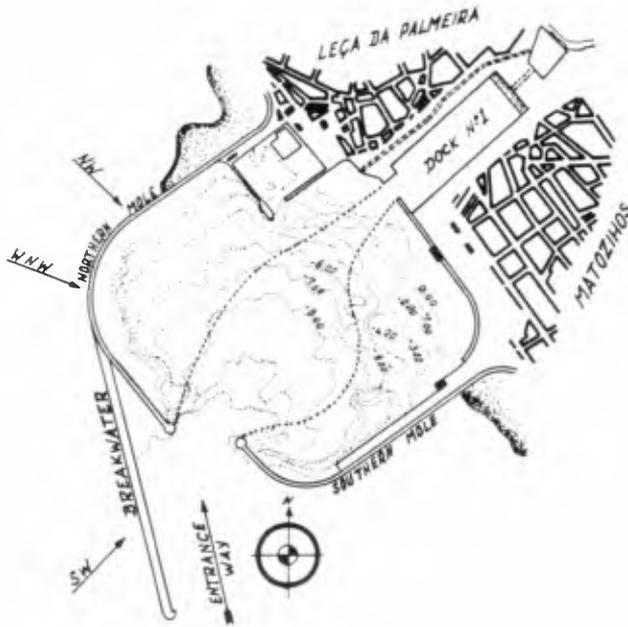
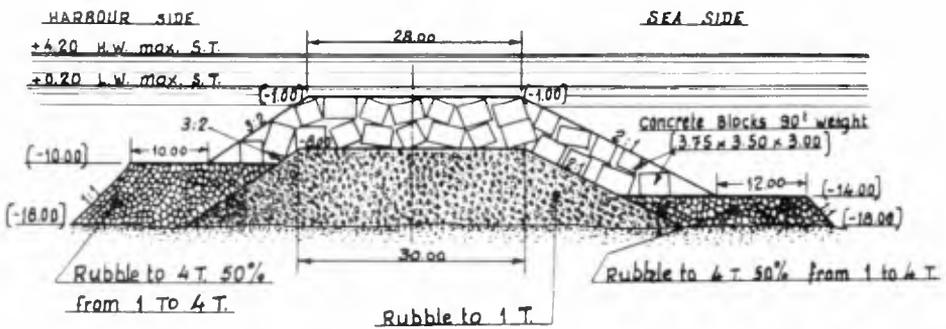


Fig. 1



PLAN



CROSS SECTION

Fig. 2

STRUCTURAL BEHAVIOUR AND THE SHELTERING EFFICIENCY 599

The maintenance charges were evaluated, for the Casablanca type, by the direct experience reported by the harbour's Authority, and for the type suggested, at Lausanne's Laboratory by a three dimensional model study in a large basin including the total extension of the breakwater (Fig. 2).

In fact, the cost of the first establishment was £ 943.000 and the maintenance charge, during the twenty-five years of the life of the work did not exceed £ 2143 yearly to maintain the crest level increased during the execution to (+ 1^m00). The allowance of 10% for sinking of the rubble mound and its revetment of 90 T concrete blocks into the bottom was reduced to less than one-tenth of the provision. The sheltering conditions of the harbour and its entrance were decidedly improved.

Wrecks no longer occurred, and the traffic of the port and fishing were greatly increased (150.000 T goods in 1933 to 2.000.000 T last year).

The maximum waves which were considered in the model study were for gales from the SW to WNW and were 10^m in amplitude and 220^m in length (prototype).

The works and model study were described in Dock & Harbour Authority, London, July 1939 and Anuário dos Serviços Hidráulicos, Lisbon 1937.