

(Paper No. 4033.)

“Harbour and Coast-Defence Works at Alexandria, Egypt.”

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*Author's Reply to the Discussion and Correspondence.*¹

The AUTHOR, replying to the Discussion and Correspondence, ^{The Author} observed that the Paper was much condensed for the large amount of constructional work covered, but it would have been impossible to go into great detail in a Paper of reasonable limits. The object of the Paper had been to emphasize the features in design that had not been prominently dealt with before.

The marked difference in the cost of dredging the Boghaz Pass in 1889 and the new Grand Pass in 1905 was mainly due to the type of plant employed. During the first operation all rock had had to be blasted, whilst the Admiralty dredgers used for the second operation had been powerful enough to excavate the rock directly. The quantity of material raised in the first instance had been 38,500 cubic yards—a small quantity in comparison with the 766,000 cubic yards dredged from the Grand Pass. In both cases the proportion of rock had been about 75 per cent. Figs. 12 and 12a, Plate 6, showed the penetration method employed in the construction of quays and moles on unstable foundations: Fig. 12 might have been clearer if the temporary surcharge had been shown. As mentioned in the Paper, this surcharge must be maintained until penetration ceased and stability was obtained with a quantity of material above quay-level at least equal in weight to that which would have to be carried eventually. This surplus was finally removed. Rubble was only used for distribution over the area to be dealt with, before tipping was commenced, in order to form a bed between the tipped material and the silt. The material used for the surcharge was sand. This system had been remarkably successful at Alexandria, and, as the silt was of great depth, it would have been very difficult and expensive, if not impossible, to construct the

¹ The Paper, with the Discussion and Correspondence upon it, was printed in vol. cci, and the references are to the pages and plates of that volume.—SEC. INST. C.E.

The Author. quays by any other method. The estimated cost of the Kaid Bey breakwater was based on the current prices of completed work in the Western Port. The Municipality owned the quarries from which the stone was obtained, the only expense being that of quarrying and transport. Very cheap labour and the use of lime for the pell-mell blocks also had largely contributed towards the low cost of construction as compared with similar works elsewhere. The life of lime-concrete pell-mell blocks in an exposed position had been proved by their use for the Mohammed Ali breakwater, which was completed 43 years ago and was still in excellent condition.

Mr. Meik had perhaps misread the Author's reference to Professor Luiggi's pressure-curve, which, as the Paper said (p. 85), was "*adaptable* to a dynamic or breaking wave of 20 feet to 25 feet in height." The curve itself was not based on waves of this height, nor, with the extreme maximum figures given by Professor Luiggi, was it applicable to the instances cited by Mr. Meik. The maximum thrust at zero must be modified to the conditions met with in any particular locality, but the form of the curve would remain practically the same. This was shown clearly in Fig. 17, Plate 6, where the maximum thrust at zero for the Kaid Bey breakwater was 20 tons per square metre, not 30 tons as shown on the maximum curve. The figures to two places of decimals were simply the equivalents of round figures of tons per square metre expressed as tons per square foot. Whilst he had not "assumed" a wave-height of 25 feet for Alexandria, he was unable to agree that it was at all unlikely such waves, and even greater ones, would be met with in exposed positions. At the risk of causing further amusement, he would emphasize the statement that the methods employed for the estimation of the strength of breakwaters seemed in many instances to be shrouded in mystery. Much public money had been wasted on abnormally strong sections on the one hand, and on the reconstruction of weak sections on the other; while comparatively few schemes had been completed without some modification of the original design. Surely this did not reveal established practice, in spite of experience on previous works. He agreed that "all that was needed for the proper design of breakwaters was a good education, acquaintance with the laws of mechanics, and years of experience"; but "laws of mechanics" were of little use if the data were obscure. Until some law for the estimation of the pressure exerted by waves was generally recognized, the alternative assumption would still lead to serious mistakes. Messrs. Schmidt, Renaud and Stevenson had been

pioneers, and Professor Luiggi's curve, based on actual experience The Author. and years of experimental investigation, was a great advance on previous work. The Author ventured to hope that by bringing the curve to the notice of those members of The Institution who were not already familiar with it, an incentive might be given to further investigation, and perhaps the rising generation might be helped to appreciate better the theory of wave-pressure. He regretted that the many calls on Professor Luiggi's time had prevented him from adding further information as to his curve.

Mr. Wilson's criticism of the change in section for the extension of the Mohammed Ali breakwater was somewhat difficult to answer. The consulting engineers concerned had advised it. Personally the Author agreed that the older well-tried section, with heavier pell-mell blocks, might have been preferable, although it would have been more expensive, owing to the larger proportion of blocks. The construction of the Mohammed Ali breakwater extension had been carried out with floating plant; but in the case of Kaid Bey breakwater the blocks had been set by a 260-ton crane running on rails extending outwards from the land over the mass. He was inclined to think that the adoption of this latter method had been an error of judgment on the part of the contractors when the slowness of construction and risk of crushing the mass were considered. With regard to the formula given on p. 86, the weight was that of the stones before they were submerged. The actual cost of the foundation of the western quay referred to by Mr. Bidwell had not been kept separately. The casing on the breakwater had stood up to the year 1914, but the Author agreed that it might have been stronger with advantage.

Mr. Brennan's point with regard to lime blocks had been very fully dealt with by Mr. Binnie. His objection to the parapet on the Abbas II sea-wall was fully justified. The Author had substituted an open railing for the extension at Anfouchy Bay, which was not only much safer, but more sightly. Dr. Cunningham's criticism of the application of the Luiggi curve revealed a weak point; but although the form of the curve could not be supposed to be the same for all waves, it gave a distinct indication of the probable distribution of pressure. This had been proved by Professor Luiggi to be correct when the curve was applied to thirteen different breakwaters. Its great value lay in the proportional pressures shown at various depths—a point often missed in design.

In reply to Mr. Leitch, the specification for the work illustrated in Fig. 9, Plate 5, read "not less than 2 tons." The text (p. 78)

The Author. explained why the large blocks had been placed on the toe of the rubble mound. The Author was unable to accept Mr. Leitch's sweeping condemnation of Mr. Malaval's application of the Croizette-Desnoyers system, or of his work generally; the facts were that the quays and walls stood, and that they had been constructed very economically and expeditiously. For the formula given on p. 86, rubble slopes of different depths had been taken, from pell-mell blocks of 20 tons to rubble of $\frac{1}{2}$ ton, and the results formed the basis of the formula. With regard to Mr. Mitchell's question, the figure of 1.56 ton had been calculated from the height of a photographed jet, caused by wave impact against a vertical wall-face during the most violent storm known. The wall was fractured, and the calculated impact to give the jet coincided with the pressure that would about fracture the masonry.