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Government of Madras.

Public Works DEPARTMENT.

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*Proceedings of the Madras Government, Public Works Department,
26th April 1867.*

No. 489. Read the following Proceedings of the Government of India, Public Works Department (Civil Works—Miscellaneous), to the Secretary to the Government of Madras, in the Public Works Department, dated Fort William, 3rd April 1867, No. 284 C :—

Applicability of Screw-pile Light-houses to the mouths of the Rivers and the Coasts of India.

Read—

Despatch No. 10, dated 31st January 1867, from the Secretary of State for India, forwarding a Memorandum by Lieutenant-Colonel A Fraser, C. B., R. E., on the above subject.

Memorandum by Lieut.-Colonel A. FRASER, C. B., R. E., on Light-houses on Screw-piles, and their applicability to the mouths of the Rivers and the Coasts of India, for the information of the Government of India.

1. Having suggested to the Government of India the propriety of lighting certain situations on the coasts of India by means of these structures, and the Government of India having adopted my suggestion in one case, and contemplating its adoption in others; and from recent observation having obtained much experience, and found that though suitable for some situations they are far from being so for others, I beg to put on record my views as to the situations for which such structures are likely to prove of the highest value, and as to those in which it would be, in my opinion, highly reprehensible to place them.

2. I believe the only experiments made practically to measure the force of the waves, are those by Mr. Thomas Stevenson, C. E., who contrived an instrument for that purpose, and who, in 1830, sent one out to me to experiment with in India at the Alguada Reef, but which, on exposure during a South-West Monsoon in that situation, was smashed up, I can only suppose, by some spar or stone driven against it. The indications however of Mr. Stevenson's "Marine Dynamometer" varied according to the season of the year, and the nature of the exposure.

The average indications registered at different places near Tyree and Skerryvore, exposed to the force of the Atlantic waves, gave a pressure, during the summer months of the years 1843 and 1844, of 611 lbs. per square foot of surface, while the average for the winter months for the same places for the same two years gave 2,086 lbs. per square foot, or upwards of *three times* that of the summer months; it also appeared that the greatest result obtained (and it is with the greatest results we have to deal, and not with averages) in those two years was 4,335 lbs. per square foot, and 6,000 lbs. have since been measured at the Skerryvore.

Mr. Alan Stevenson, C. E., who built the Skerryvore Light-house, observes in his Treatise on Light-houses (page 30) "a primary inquiry as to towers in exposed situations is the question, whether their stability should depend upon their *strength* or their *weight*, or, in other words, on their *cohesion*, or their *inertia*."

In preferring weight to strength, we, Mr. Stevenson observed, more closely follow the course pointed out by the analogy of nature, and that the effect of mere *inertia* is constant and unchangeable in its nature; while the *strength* which results even from the most judiciously disposed and well executed fixtures of a comparatively light fabric, is constantly subject to be impaired by the loosening of such

fixtures, occasioned by the almost incessant tremor to which structures of this kind must be subject from the beating of the waves.

These principles were adopted by Smeaton in building the Eddystone, though Smeaton perhaps did not fully adopt them, for there is probably not sufficient weight in the building, and he trusted something to strength of joggles and dove-tailing, &c., whereby its vibration is very great, and nine years ago when I visited it, and when it was about 100 years old, it was very leaky.

These principles again were adopted by Robert Stevenson (the father of the Alan who speaks above, and of the Thomas who invented or applied the Dynamometer) in his building of the Bell Rock Light-house, and more effectually still by Alan Stevenson in the Skerryvore, and which I humbly followed in the construction of the Alguada Reef Light-house. So long as the foundations of the two latter stand, they may be considered (humanly speaking) absolutely safe for all time against the force of any waves, or against the force of anything which the waves may drive against them.

My own experience (and no living Engineer has more on these points) goes altogether to confirm the experience of the above celebrated Light house Engineer as to the value of *inertia* over *strength* for Light-houses in exposed situations.

3. Mr. Gordon advocated the suitability of an iron Light-house for the Skerryvore Rock, which, moreover, he undertook to build for *one-tenth* of the cost of the stone building which was erected by Mr. Stevenson. We know that the Skerryvore cost £87,000, and the Alguada Reef over £90,000, but we now also know that this same Mr. Gordon has had the opportunity of putting up a structure on his own plan on the Great Basses Rocks off Ceylon, on an original estimate of £18,689, which has now been abandoned after an expenditure by the State of £54,000.

Mr. Alan Stevenson briefly enumerates a few leading facts which bear upon the fitness of an iron structure for such a situation as the Skerryvore:—

1st. A temporary barrack, similar in construction to that which stood so long on the Bell Rock, and afterwards for several seasons at the Skerryvore itself, was carried away in one night.

2nd. Stones, some of which weighed as much as 5 tons, were swept by the waves over the top of the rock; and much floating wreck-timber has been seen to pass close to it.

3rd. The force of the waves, as indicated by the Marine Dynamometer, has amounted to 6,000 lbs. per square foot.

4th. Two iron beacons were successively destroyed on the Bo-pheg Rock in Hynish Bay, 12 miles land-ward of the Skerryvore Rock, one of which was of a pillar form, and the other was a cone of iron-plates, like that proposed by Mr. Gordon, having the lower part of the void filled. Before the plate-beacon was carried away, a hole of two feet in diameter was broken through one of the plates, most probably by a heavy spar urged end on by the waves.

I might add much of my own experience to that of Mr. Stevenson, but content myself by saying that I have seen, at the Alguada Reef, stones over two tons in

weight driven along the rocks by a summer sea; and that, in the South-West Monsoon, similar stones have been whipt out of the foundation pit of the Light-house, 5 feet below the surface of the rocks, and swept along the rocks; and I have also seen the wreck of one of my own lighters lifted bodily on to the rocks in ordinarily bad weather of the North-East Monsoon.

4. The principle of construction of Light-houses on Screw-piles is to obtain the least possible resistance to the force of the waves, and no doubt they generally accomplish this almost entirely, for they *create* no sea, and present for resistance only a pile of, at the outside, 8 inches diameter: the waves pass between the piles, and do not run up the Light-house as they would when acting on a stone or other building of solid construction. But the value of the non-resistance of the piles is, in a great measure, done away with when the foundation on which they stand creates the force we wish to avoid in structures dependant for their stability, not on their *weight*, but on their *strength*; and such structures are quite unfit for situations, such as the Bell Rock, the Eddystone, the Skerryvore, the Alguada Reef, the Great Basses off Ceylon, and the Prongs, forming the south-west extremity of the north-western side of Bombay Harbour.

"There is" to quote again from Mr. Alan Stevenson, "undoubtedly reason to fear that in structures of great height, urged by the continued force of the waves and winds, a gradual deterioration of the fixtures may result from long continued tremor, or that the pillars might suddenly sustain very serious injury from the impact of heavy bodies thrown against them by the waves: and while in proportion to the difficulty of the situation, the expense of the stone structure would increase, so the undesirableness of being forced to renew any structure would increase also; and thus, while in many such places, the iron Light-house may be the most convenient and least expensive in prospect, the stone tower is the more satisfactory and more durable when completed."

5. I wholly agree with the above remarks of Mr. Stevenson, and though he did not intend them to apply to Light-houses on Screw-piles which were then of recent invention, yet they are obviously applicable to them in such situations. I have no doubt in my own mind that if, instead of a stone Light-house on the Skerryvore or the Alguada Reef, the Basses, or the Prongs, a Light-house on piles were to be built, and a wreck or a heavy spar were to get jammed in amongst the piles and tie-rods, with the sea pounding at it with a force of between 4,000 and 6,000 lbs. per square foot, that such a building would inevitably be carried away if exposed to such pounding for any long period. The situation would not admit of the use of any boat, and consequently great risk of life would be involved in building such Light-houses in such situations, while the difficulty of keeping them painted and in repair would be in proportion to the difficulty of approach to them.

6. This brings me to the point at which I would consider the situations for which piled Light-houses on Mitchell's Screws would be, in my opinion, suitable. There can be no doubt that there are many situations for which a stone or other solid structure could not be adopted, or if it could, it would be of such expense that it would be out of the question, while the adoption of a permanent structure, instead of a floating light, is most desirable on the score both of efficiency and economy.

Light-houses on Screw-piles are, in my opinion, suitable for any situation not exposed to the force of heavy seas, and they may be employed even with such exposure, provided they are placed outside the lines where the waves break, and have acquired the momentum so destructive to any thing but stone of adequate mass and weight. That is, I should be quite prepared to place a Light-house of this construction in any situation whatever, provided no great height was required, and that it was in water of a depth not less than 3 fathoms or more than 5 fathoms at low-water where boats could at all times be made available. The waves, under these circumstances, do not acquire the force, nor could they drive anything against the structure with a force sufficient to destroy it, and when anything is driven against it, it does not remain there but leaves it immediately. The structure itself, moreover, offering little resistance, creates no sea, and no force to cause vibration, which is the chief cause of deterioration.

7. Light-houses on Screw-piles may therefore, in my opinion, be erected in any situations (having suitable ground for the screws) in a depth of water between 3 and 5 fathoms, with a total height not exceeding, where hurricanes may be anticipated, 80 feet, and a height to floor of dwellings of not less than 30 feet above high water.

They should never be built on rocks, with great exposure, over which in times of commotion the green seas sweep.

They should never be built in-shore, if such shore be exposed to the open sea between high and low-water marks; though they might be built near such shores in 3 or 4 fathoms of water at low-water.

The Skerryvore Rock is only about 8 feet above high-water, and is washed by the full force of the North Atlantic.

The Alguada Reef and the Great Basses, in analogous situations in opposite sides of the Bay of Bengal, are not quite so high out of the water as the Skerryvore, and with nothing between them and the South Pole, are swept by the periodical turbulence of the Indian Ocean by seas driven possibly by such a cyclone as happened, more to the northward, in 1864; and yet I have seen a design for a Screw-pile Light-house for the Basses with the dwellings only 20 feet above the rocks.

The Prongs, the sea-ward extremity of the shore on the north-west side of Bombay harbour, have nothing between them and the South Pole, and are similarly liable to be swept by the waves of the Indian Ocean from the most dangerous quarter, and yet it is proposed, I believe, to build a Light-house of great height on Screw-piles at about low-water, so that it should feel the full force of the breaking waves during the whole of its (probably short) existence.

None of these situations, or any similar situations, are, in my opinion, suitable for iron structures of any kind which have not weight to resist the acquired force of the waves, or what may be brought against them by such acquired force.

8. I am now superintending a Light-house on Screw-piles for the Krishna Shoal off the Baragoa Point, in the Gulf of Martaban, and I annex a drawing of what it is intended to be. But here there is 4 fathoms of water at low-water and a suitable bottom. I have recommended similar structures of a less expensive charac-

ter for the shore at the mouth of the Rangoon River, where it would take a very long time, and be very expensive to erect masonry buildings.

I have further recommended a Screw-pile Light-house on an exactly similar plan as that for the Krishna Shoal for the Oyster Reef off Akyab; but then I propose to put it inside the Reef in deep-water of from 4 to 5 fathoms. Any stone or solid structure on this Reef, which has at its highest point a fathom of water over it, would be certainly ten times the cost of the iron Light-house.

Similarly, the tails of the sands at the mouth of the Hooghly and Mutlah, in from 3 to 4 fathoms of water, would be, if the bottom be suitable for the screws, very proper situations for these Light-houses on Screw-piles: and I hope by careful superintendence in this country of this one Light-house, to secure a type of edifice which shall not only be suitable to the Krishna Shoal, but, with more or less variation, be suitable to all situations where they can, or ought to be, put up, both as regards strength and fitness to the climate and their purpose.

These Screw-pile buildings would be also peculiarly adaptable to such seas as the Red Sea, the Persian Gulf, the Malacca Straits, and the mouths of the great rivers debouching on the Madras Coast, either outside or inside the line of surf, &c., &c.

9. Finally, I strongly recommend the use of such buildings on account of their comparative cheapness, and the celerity with which they may be constructed in almost all situations where other material or labour is difficult to obtain, and where they are not exposed to that force which is acquired by the breaking of heavy ocean-waves, and which force is, in my humble opinion, irresistible for any long period by anything but mass and weight. The buildings on piles of solid wrought-iron are designed to offer no resistance to the sea, and to place them in situations where the ground on which they stand offers that resistance, and causes that force which they are specially designed to avoid is a mistake which the simple "feeling" (by which word Smeaton expressed "professional experience") of an experienced Light-house Engineer, in the absence of reliable data in regard to the force of breaking ocean-waves hurled on a beach or rock, with a probable force of nearly 3 tons to the square foot, would not allow him to commit.

ORDER.—Ordered, that copies of the Memorandum be forwarded for information to the Governments of Madras, Bombay, and Bengal, and the Chief Commissioner of British Burmah.

(Signed) C. H. DICKENS, Colonel, R. A.,
Secretary to the Government of India.

*Proceedings of the Madras Government, Public Works Department,
26th April 1867.*

No. 490.

ORDER THEREON, 26th April 1867, No. 1,243.

CIVIL WORKS, No. 42.

Communicated to the Marine Department and to the Superintending Engineers.

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Marine Department.
„ Superintending Engineers.
„ Editor's Table.

Exd. T. O'Connor.

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Comm. to the
Marine Dept. and
to the Superintending
Engineers -

W. J. P.

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Genl. St. George
26th April 1867

Proceedings of the Madras Government, Public Works Department,
26th April 1867.

No. 490



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Pro. of Govt. for April
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GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

CIVIL WORKS.

To

The Secy. B. Govt. Madras

No. 224C.

Dated April 3, 1867.

Received *12th April 1867*

Applicability of Screw-pile Lighthouses to the
mouths of the rivers and the coasts of India. -

1213-26th April 1867

With an order

No. 489-490

12th April 1867 - 22 17