

tus therefore cannot fulfil their object, which is to give simultaneous issue to all the steam which a boiler can produce when it has reached a determinate degree of tension, and thus to prevent all danger of explosion. To fulfil this purpose they ought to be at least six times, and in some cases twenty times larger than the rules prescribe.

*L'Institut.*

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*Durability of Cast Iron in Sea Water.* By E. B. WEBB, M. Inst. C. E., &c.

From the Lond. Civ. Eng. and Arch. Jour., Aug., 1862.

Mr. Webb has given special attention to the durability of cast iron in sea water, and the subject is one of such importance that we extract his observations; while not professing to show that all cast iron may be trusted to withstand the deteriorating action of the sea, our author brings forward several instances in which its judicious employment has been proved by its remaining uninjured after many years submersion.

Cast iron in sea water is liable to two descriptions of deterioration, generally by the absorption of oxygen, and occasionally, with certain qualities of metal, by a softening of the outer surface.

The oxidation of cast iron in sea water does not proceed rapidly, even when its surface is unprotected and its quality that most favorable for a union with oxygen. An idea of the rate of oxidation may be formed from the following statement by Mr. R. Mallet (as the result of numerous experiments), that "cast iron freely exposed to the weather at Dublin, and to all its atmospheric precipitations, was corroded nearly as fast as if in clear sea water, when the specimens in both cases were wholly unprotected."

In iron breakwaters, the question as to durability will refer chiefly to the parts below low water; for the protection of the superstructure against slow and unimportant oxidation may be readily insured. It has been stated, that the oxidation of iron surfaces continually covered with water goes on more slowly than when the metal is exposed alternately to air and water. In addition to this circumstance, favorable to the easy protection of ironwork standing in the sea, it will be found that in the majority of localities the sea itself provides, in the shape of mollusks, an excellent protection to the submerged portions.

The softening of cast iron is a process not clearly understood. Cast iron will soften in the cylinders and pipes used in mines, as well as in piles standing in sea water. After softening under sea water it will at times become hard again on exposure to the air. Cast iron, however, is very far from being generally liable to the process of softening.

In consequence of the great variety in the quality of cast iron, instances are not wanting which apparently support directly opposite opinions. Cast iron has been taken up after immersion in sea water, utterly decomposed. In many such cases, it is known that the iron has been purposely cast of the softest metal, and in others it may airily be presumed that soft metal has been employed. On the other

hand, there are numerous instances of cast iron having remained perfectly sound and uninjured after an immersion for many years in sea water. From very numerous examples of long immersion without injury, the writer will select a few which he has personally examined.

*Dock Gates, Sheerness.*—There are several pairs of cast iron dock gates at Her Majesty's dock-yard, Sheerness. They were designed by the late Mr. Rennie. The heel posts, mitre posts, and ribs, are of cast iron. The gates are sheeted from top to bottom with cast iron plates, perfectly water-tight. Three pairs of gates have been exposed to the action of sea water since 1821, and a fourth pair since 1827.

The writer examined these gates in January of this year, 1862, and he found that the framing and plates were in perfect condition. From the dock-yard officials he learnt that no portion of the cast iron had ever been replaced, in consequence of deterioration of the metal, and that no plate had given way, although there is a head of water equal to 26 feet at spring tides. Three pairs of these gates have, therefore, resisted the action of sea water, uninjured, for fully forty years, and a fourth pair for thirty-five years.

The writer observed, however, that the cast iron sector plates, against which the gates shut, are softened in places to some little extent, but only where the iron is in contact with a mass of lead, which has been used to form a water-tight joint; the galvanic action created by the contact of the two metals having, doubtless, caused the softening of the iron.

At Chatham, the writer saw a number of iron castings which had been removed thither from a dock at Pembroke, where a caisson has replaced the gates. After an immersion in sea water at Pembroke for many years, these castings are found to be in so perfect a state, that they will shortly be put in use at the new entrance to No. 1 dock at Chatham, there again to be exposed to the action of sea water.

*Lowestoft Harbor (Basin Entrance).*—The late Sir W. Cubitt having witnessed the rapid destruction of timber in the sea at Lowestoft, and being satisfied as to the durability of cast iron in sea water, determined upon casing the entrance of the Lowestoft basin with cast iron piles. The work was commenced in 1832, under Mr. George Edwards. The writer examined these piles last year, and he found them uninjured. They are, for all practical purposes, as sound and as perfect as when they were driven—upwards of 28 years ago.

*Southend Pier (Extension).*—Mr. Jas. Simpson (Past-President of the Institution of Civil Engineers), in designing the extension of this pier, after careful consideration of the durability of cast iron in sea water, selected that metal for his piles. The extension was executed in 1844. In February, last year, the writer examined these piles; he found them in a most perfect state. They are square, and the angles are as sharp as when they left the foundry. Mr. Simpson specified the quality of the iron from which these piles were to be cast, because he found, from examination of specimens of cast iron which had been exposed to the action of sea water, that the durability depended upon the quality. These piles, after having been exposed to sea water during 17 years, are perfectly uninjured.

*Herne Bay Pier.*—The pier at Herne Bay, nearly three-quarters of a mile in length, was designed by the late Mr. Telford. It was built of timber in 1831. After standing for about seven years, the piles were generally so far destroyed by the worm, that it was decided to use cast iron, to a great extent, in the repairs. Accordingly, in 1838, a great number of cast iron square piles were driven. Very recently the writer examined this pier. He found the cast iron in a most perfect state. The angles of the piles were sharp, and the surface as smooth and as sound as when the castings left the foundry. The piles, as usual, are covered with shell-fish, which keep the surfaces moist during ebb tide. Not more than one-half of the whole piles in the pier are of iron; those of wood are either cut through by the worm, or are under that process of destruction. The timber piles have required constant repairs and renewals. Upon the cast iron not a shilling has been expended. The pier, in consequence of the destruction of the timber, which is immersed in the sea, is in a most dangerous condition. Had Mr. Telford, in the first instance, selected cast iron for the piles of his pier, the substructure would have been as sound to-day as when put down in 1831. With the exception of the cast iron piling, which has been under the action of sea water 23 years uninjured, this pier may now be termed a ruin.

*Margate Jetty.*—A jetty erected at Margate in 1831 rested on timber supports fitted into cast iron piles. These piles did not stand sufficiently high from the bed of the sea, and the lower portion of the timber, exposed to sea water, was destroyed by the worm. In 1853, nearly all of them were taken up and sold for old metal at the price of pig iron; and in the same year, a new iron pier, resting on cast iron piles, was erected by Messrs. J. B. and E. Birch. A number of the old piles, after having been immersed in the sea water for upwards of 20 years, were last year to be seen on the pier at Margate. The writer has carefully examined them; they are as sound as when they left the foundry; in no instance can any softening of the metal be detected. A still stronger proof, however, is to be found in some of the cast iron piles of the old jetty, which are still *in situ* at the head of the present jetty. In these piles no deterioration whatever can be discovered. The shell-fish with which they are covered form a perfect protection against oxidation. These piles have stood in the sea during 30 years, and are perfectly uninjured.

If, then, numerous and undoubted examples of cast iron do exist which have withstood the action of sea water, without any deterioration, for upwards of a quarter of a century, we must come to the conclusion, that where cast iron has been injured or decomposed in open sea water within a less period, the cause is to be found chiefly in the quality of the iron not being suitable for the work in which it is placed. The power, therefore, of various classes of cast iron to resist the action of sea water, will vary according to quality.

The cast iron used by Mr. Murray in the dock gates of Sunderland may be cited in proof of the foregoing statement. After an immersion for some years, the rollers under the gates were found to have been

acted upon by sea water, but other portions of cast iron placed in the body of the gates remained uninjured. As the rollers had to be turned in the lathe, they were doubtless cast of soft material, but the other portions of cast iron, not requiring to be cut by tools, were of harder metal. The former gave way, but the latter remained perfect.

The words *cast iron* admit of almost the same latitude of signification as the word *timber*. Because we dare not use poplar on account of its liability to decay, it does not follow that no structures are to be erected of other qualities of wood.

At a meeting of the Institution of Civil Engineers (February 13th, 1844), Mr. J. Simpson stated, that with good grey cast iron, having a good surface, little injurious effect from the sea water was to be dreaded. He also stated that he was then about to use cast iron extensively for piles, and that he had examined cast iron piles which had been in sea water for 16 years without any detrimental effect being produced.

It appears that the action of sea water is powerful in the greatest degree when the iron is composed of large crystals, and especially when there is irregularity in the crystallization. It may be said that the softer the iron the greater is the liability to decomposition.\* Between the limits of extreme softness and decay on the one hand, and extreme hardness and durability, with brittleness, on the other, we have to make the selection. It has been stated† that chilled cast iron corrodes faster than green sand castings, that all castings intended for use in sea water should be cooled in the sand to insure uniformity in the crystals, and that Welsh iron is the best. From a careful investigation of the subject, the writer has arrived at the conclusion, that a strong description of cast iron may be employed, capable of enduring the action of sea water for an indefinite length of time.

In cases where, from the use of an unsuitable quality of iron, or from contact with some other metal (such as lead or copper), softening of the iron has taken place, it will generally be found that the glazed skin produced by the sand of the mould in the process of casting, has been removed by tools, accident, or wear. An iron breakwater can be erected without any removal of this protecting glazed skin; no holes will be required to be bored, and no surfaces cut by tools.

As an instance of the detrimental effect of placing another metal in contact with cast iron, it may be stated that the cast iron plates affixed to ships bottoms (according to the proposition of Sir H. Davy) for the protection of the copper sheathing, rapidly became softened.

\* In Brande's *Manual of Chemistry*, (vol. i. p. 754, edition 1848.) the following remarks are made upon cast iron:—"White cast iron is very hard, and when broken, of a radiated texture. Acids act upon it but slowly, and exhibit a texture composed of a congeries of plates, aggregated in various positions. Grey or mottled cast iron is softer and less brittle; it may be bored and turned in the lathe. When immersed in dilute hydrochloric acid, it affords a large quantity of black insoluble matter, which Daniell considers as a triple compound of carbon, iron, and silicium, and which has some very singular properties. The texture of the metal resembles bundles of minute needles."

† In a paper inserted in the "*Edinburgh Philosophical Journal*," (vol. vii. p. 201.) Dr. McCulloch remarks, that "the blackest pig-metal appears to yield the greatest quantity of black-lead, and in the most solid state."

The "*Mining Journal*," of January 11th, 1862, under the head of "*Artificial Plumbago*," states, that "for some time past, Dr. Grace Calvert, F.R.S., has been engaged in experimenting upon the composition of a carboniferous substance existing in grey cast iron, or, to use a more popular definition, in producing plumbago from cast iron. The effect of his experiments has been to arrive at results which throw much light upon the chemical composition of the substance, proving it to be composed of iron, carbon, nitrogen, and silicium."

‡ Minutes of Proceedings, Institution of Civil Engineers, vol. i. p. 72 (Session 1840).