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Description of an improvement on the Bridge patented by ITHEIL TOWNE, Esq., the term of which patent has expired. By ITHAMAR A. BEARD, Civil Engineer.

Elevation.

The Improvement consists in the Upright Plank, and the Iron Bolts. The Bolts are marked with a full dot (•) The Treenails marked with an open dot (◊)

Scale, twelve feet to an inch.

In 1836 I was requested to advise the best construction for a bridge to be erected over a branch of the Androscoggin river, at Brunswick, Maine, from the main land to an island.

Accordingly, I recommended Mr. Towne's bridge; and in making a model for the purpose, it occurred to me that a great addition might be made to the strength and durability of the bridge by the addition of a pair of upright planks (one on each side of the X work;) over one half the intersections, these planks to stand perpendicular like posts, and the treenails or bolts to pass through and connect the X work and the uprights at each crossing.

My object and intentions were to prevent, in the greatest possible degree, the depression of the bridge, and, on trial, I found my expectations fully realized.

This bridge is 101 feet long, in a single span, and is built with a single travel only, twelve feet wide in the clear, and the travel of the bridge is arched, or crowned, sixteen inches in the centre above a level with the ends.

For the better convenience of drafting I have made the accompanying plans level from end to end, and in fact, in a bridge of this structure I cannot see that any benefit or advantage is derived by arching.

In this bridge, instead of the ordinary treenails, the principal intersections are firmly secured with bolts made of one and a quarter inch round iron, (Bank's best,) with cast iron washers, six inches in diameter, under the heads and nuts; a single bolt being used at each intersection.

There is a vast advantage in using the bolts, with heads and nuts, over the treenails, for, it not only holds the work together more firmly at first, but it likewise furnishes the means of keeping it always firm and close, for as the woodwork shrinks by seasoning or age, as is invariably the case, even if tolerably seasoned when worked, by turning up the nuts upon the screws occasionally, it may always be kept as compact as when first built.

Another advantage is, that the bolts need not be half so large as the treenails, and fewer in number are required, which very much saves the strength of the plank through which they are inserted.

The cost of building one of these bridges with bolts instead of treenails will be somewhat greater, but for a term of twenty or thirty years, I am fully of opinion that a bridge may be supported with less expense than if built wholly with treenails.

The bridge herein described was built by Capt. James Derby who now owns the Island and Mills thereon, and the work was most thoroughly put together in every part. The using of bolts instead of treenails was his suggestion.

After the bridge was completed, and before the trussels on which it was built were taken out, I set my levelling instrument and took the elevation of the travel of the bridge in the centre, and again after the trussels were removed, and it settled seven-tenths of an inch only.

This bridge has been in constant use ever since it was built, for teaming over with heavy loads of lumber from the mills on the Island, and it now stands as perfectly firm, true, and straight as it did when first completed.

To give a more clear idea of the cost of a bridge so constructed, I will insert the number of pieces and dimensions of all the materials of which this bridge is constructed, and also the cost for materials and labour as nearly as I can obtain them.

Timber and Plank.				Feet.
8 Posts	20 feet long, 16 by 16 inches.			3413
2 Headsticks	18	"	20 " 20 "	1200
120 Planks for × work	21	"	10 " 3 "	6300
116 Do. Uprights	12	"	8 " 4 "	3712
20 Ranges of Stretchers	101	"	9 " 3 "	4545
15 Crossills	26	"	9 " 6 "	1755
15 Do.	16	"	9 " 6 "	1050
11 Cross Caps	14	"	8 " 8 "	821
22 Braces	16	"	6 " 4 "	704

60 Do. 7 feet long, 6 by 4 inches. 840
 Planking of the travel, 101 feet long 12 feet wide 3 inches thick 3636

Plank and Timber, in board measure, 28,006

Making allowance for waste, say 30,000 feet, worth here, at that time, \$15 per thousand.

All the timber of this bridge is white pine.

The travel of this bridge is laid with the length of the plank lengthwise of the bridge. I do not think the plank will be so durable laid in this way as they would be if laid crosswise of the bridge, especially for heavy loads, and if planked crosswise a set of stringers must be laid on the crossills; say 5 stringers, 101 feet long 9 by 6 inches—2272 feet.

Taking the lumber of this bridge as it is 30,000, a \$15 per thousand \$450 00
 632 cast iron washers, $3\frac{1}{4}$ pounds each, 2054 pounds a 5 cts. 102 70

304 Bolts 24 inches long }
 12 " 34 " } weighing 2600 pounds.

Estimation for heads, nuts and waste 400 "

Say 3000 a 10 c. including making 300 00

The labour was done by hands hired by the day, at an average of about \$1 50 each per day, board included, and cost as nearly as can be estimated, about

375 00

\$1227 70

Equal to twelve dollars a foot in length very nearly.

It is estimated that a bridge with two travels, fifteen feet wide each, with two sidewalks outside of the $\times$ work, and without a roof, may be built for twenty dollars a foot in length; timber and labour being at the same value as above rated.

To this must be added the cost of abutments and piers and of a roof if the bridge is to be covered.

There are no bridges in this section of country that stand so well and so durable as the "Town Bridge," and it is getting into general use.

Brunswick, Maine, March 27, 1840.

Hydraulic Works at Algiers. By M. POIREL, Engineer of Bridges and Roads.

[Translated from the *Annales des Ponts et Chaussées* by W. H. Emory, Jr., U. S. Topog. Engrs.]

The port of Algiers was established as far back as the year 1530, by Cheredin, brother of Barbarossa. Having made himself master of a little island, in front of the city, which the Spaniards had fortified, he resolved, in order to secure it, and at the same time to make, at Algiers, a harbour that would afford protection from the winds and from the swell of the sea, to unite it to the town by means of a jetty. This is called the Cheredin jetty, and is two hundred and twenty-three yards long and one hundred and twenty-seven yards wide. Its direction is nearly east north-east; or west south-west.

Besides the Cheredin jetty, another has been built on the prolongation of the island, which protects the harbour from easterly winds, and is called the mole. It is one hundred and seventy-four yards long, and forty-five yards in its greatest width. This mole runs north-east and south-west. These two

jetties with the little mole on which the Lazaretto stands form the boundary of the basin. It contains forty thousand seven hundred and twenty-two superficial yards, and can float sixty vessels, of which about thirty, may be vessels of three hundred tons, and some few, eight hundred tons. Vessels of a larger class anchor outside the basin. The greatest depth of water is sixteen and a half feet; but this may be increased by dredging. The Cheredin jetty and the mole were found in a state of complete dilapidation when Algiers fell into the hands of the French. These two works constructed of loose stone, (sometimes called rip-rap in the United States,) were levelled to their base. The Deys were in the habit every year of having the stones replaced which were carried away in the winter by the sea.

Laugier de Tassy, one of the most faithful historians of the Algerine regency, who resided there in 1727, says:—

“The great mole (the Cheredin jetty,) being entirely exposed to the north, to prevent it from being carried away by the furious swells of the sea, which roll up the sand bank, stretching along this mole and out into the sea, they were obliged to keep the slaves of the beylick employed the whole year carrying hard stones from a place near point Pescade, to put them along the mole. The sea soon carried away the stones thus deposited, but care was always taken that they should be replaced.”

Large magazines of military supplies are placed on the Cheredin jetty and it naturally claimed the first attention of government.

The preservation of these magazines required that the loose stone upon which they rested, at the base of the jetty, should be secured.

This undertaking was confided to M. Noel, the engineer, in charge of the hydraulic works at Toulon, from which he was temporarily relieved.

He rebuilt the entire body of the jetty to a height of sixteen and a half feet above the water, with a thickness of six and a half feet. The new masonry is of the very best kind and possesses great solidity; unfortunately the insufficiency of funds placed at the disposal of the engineer and his limited time did not permit him to turn his attention to the foundation of the jetty which will soon require considerable repair.

The extremity of the mole, called the chop, in which the sea made a large breach, was repaired in 1831, but the new masonry being built upon the fragments which the action of the sea had brought down, was entirely destroyed by the first storm in the winter of 1832. All the repairs made to the top of the work were necessarily liable to the same catastrophe, as the base upon which they rested was insecure. It became necessary, therefore, before proceeding farther, to reconstruct the base permanently and durably.

The locality did not permit the engineer's resorting to the ordinary means of establishing a foundation by throwing over loose stones, (rip-rap.) The shore to the west, where the quarries are, has not a single creek or harbour where a vessel could load; it is open to the ocean and skirted by a reef of rocks which make the landing dangerous even in a calm. The transportation of blocks of stone could only be effected by carriages, a tedious and difficult operation with masses, which, to resist the action of the waves, should measure at least four cubic yards. Besides which it would have been necessary to carry these blocks through the most frequented and populous part of the city, very much to the inconvenience of the inhabitants passing to and fro. Another difficulty presented itself, even if the obstacles to an easy transportation had been overcome. To give sufficient stability to the work at the end of the mole, a long slope of at least one in ten was necessary, which would have entirely obstructed the navigation, as the entrance to the basin was already very narrow, being

only one hundred and thirty-four yards wide, measuring from the end of the mole on which the Lazaretto stands, to that of the work in question.

Under these circumstances, the engineer was obliged to resort to other expedients, and he was thus led to form and execute a new plan for establishing foundations at sea, which five years experience of the works at Algiers has proved to be, according to all accounts, superior to all those which have heretofore been put in practice and particularly to those made of rip-rap work; a method much approved of since the construction of the Cherbourg and Plymouth breakwaters, the two most important maritime works executed in modern times.

The principle feature of this plan is the use of blocks made of *béton*. These blocks are of two kinds; one being constructed in the water at the place it is intended to occupy, the other made on shore and launched.

The first is made by pouring the *béton* into cases without bottoms, sunk on the place where the block is to rest. The frames of these cases as shown in the annexed cut, are made by putting together pieces of scantling, in a rectangular form, and the sides are made by nailing to this frame two courses of plank placed at right angles to each other. The lower edges of the cases are cut out to fit the profile of the surface on which they are to rest. They are lined with tarred cloth, throughout the whole extent of the inside up to the level of the water. The cloth at the bottom is allowed sufficient fullness to accomodate itself to the inequalities of the ground. The cases are thus, in fact, converted into cloth sacks, the sides of which are strengthened by the timber work on which they are stretched and fastened. The cloth sacks enable the mass of *béton* to accomodate itself perfectly to the surface which receives it, the inequalities of which serve to bind together the rock forming the bottom, and the *béton*. This is a great advantage in the use of these cases, for with the flat bottomed ones generally used, it is necessary to level the surface to be built upon, which is a difficult and uncertain operation.

The cloth bottomed cases are built upon stocks, launched and floated to the place they are to occupy. They are then sunk by means of small wooden boxes, one foot square, filled with cannon balls or pig-iron strung entirely around on the outside of the case, about one foot and a half from the top, by means of a cable passing through iron rings fixed in the uprights.

The arrangements for sinking the cases is shown in the annexed figure.

A similar use of *béton* was made by the Italians to prevent the disinte-

gration of masonry immersed in water. They filled, with *béton*, bags similar to those used in fortification for making earth defences, and placed them compactly, one upon the other, and in such a manner as to fill up the inequalities of the surface on which they rested. The cement which oozed out through the interstices of the cloth, bound the little rolls of *béton* together and soon formed a very compact and durable mass. The cloth between the joints rotted and disappeared in a few years. On one occasion, they filled a much larger sack with *béton* than those above described, and threw it into the sea in stormy weather; some days after the storm had subsided they found this block very hard and strong. From the result of this experiment it was natural that the adoption of very large blocks of *béton* should be thought of, but the difficulty consisted in making bags of those dimensions which would not burst, and fixing them in position, while being filled with *béton*.

When the case is moored, the *béton* is lowered and deposited in it by means of a trough, which has a vertical and semi-rotary motion communicated to it by a cylinder worked at each end by a crank. This trough which contains a little more than a cubic yard, gives the advantage of putting in the case a large quantity at a time. The operation is thus made more rapid and there are fewer seams.

The *béton* blocks made on shore are moulded in cases consisting of four sides made of thick planks and lined on the inside with another course of plank jointed together at the bottom and removable at pleasure. The bottom rests upon two large sills connected transversely, forming an inclined plane which terminates at the point where the block is to be launched. These cases like the others, are entirely empty and without shores. When they are filled with *béton*, and it becomes sufficiently hard, the sides are taken off and the block thus stripped is launched into the sea.

The mortar used in the large cases with cloth bottoms, is formed of one part fat lime and two parts of Italian puzzolana; that used for blocks on shore is composed of puzzolana and sand in equal proportions.

The lime should be made from the grey transition limestone, fine grained and very hard; slaked in the ordinary way, and reduced to the consistency of thick paste, it absorbs two and a half times its weight of water. Its bulk is increased in the proportion of 1 to 1.8.

The puzzolana is the same as that used along the Mediterranean coast in the formation of hydraulic mortars. It is to be found in the neighbourhood of Rome. The best comes from Saint Paul's cave, near the church of that name. This puzzolana is brought by wagons to the Tiber, and thence by batteaux to Civita Vecchia, whence it is exported. It is sent abroad in the natural condition in which it is found, the pieces varying in size from that of an egg to the smallest grain of sand. M. Jullien, the engineer, found by experiment that the very finest grains were the only ones that could be used with effect in hydraulic mortars, and that when it was used in grains as large, for example, as the largest grains of sea sand, it was as ineffectual as the sea sand itself. From this it appears to be necessary that the finest grained puzzolana alone should be used in hydraulic works; and as its efficacy, and quickness in hardening are in proportion to the fineness, too much pains cannot be taken to pulverize it.

Acting on this principle, the puzzolana brought from Italy to Africa for the work on the mole was sifted at Algiers before being used. One half, forming the residue, was ground in a mortar mill and sifted again, leaving a residue of one tenth.

That ground and sifted was of a quality inferior to that furnished by the

first sifting. The price of the puzzolana delivered at the work was thirty-six francs per cubic yard, and the cost of sifting, grinding, &c., twelve francs, making the total cost forty-eight francs.

The cost of labour at Algiers, independently of the inferior quality of the puzzolana obtained by trituration, and the consequent increase of expense, made it desirable that it should be sifted at Rome and the refuse left there. The soil on which this city and its environs stand, is composed of this material, and is of course very cheap. The only difference in the price would therefore arise from the cost of sifting, which could be more than balanced by the freight saved in leaving the refuse.

Influenced by these considerations, the author, on the requisition of the Governor General was authorized by the Secretary of War to repair to Rome and superintend in person, the details of the operation. He there fixed up a number of strong bolting cloths pierced with small rectangular holes. The price of sifting one cubic yard of puzzolana with labour hired of the pontifical government, was about twenty cents.

The contractor who has leased from the Roman government, the monopoly in the puzzolana trade, regarding the project as impracticable, asked an exorbitant price for taking charge of it, but as soon as he discovered it was both easy and cheap, he came forward and offered for the future to send none but the sifted puzzolana to Algiers. It was delivered there in 1837, in this state, for forty-two francs the cubic yard, and could, without doubt, be delivered for forty francs. By adding one half sand, quite as good a commodity as the rough puzzolana is produced, and you get for twenty francs what formerly cost thirty-nine. At this price this material is likely to supersede all the hydraulic lime and artificial cements made at the different localities. It is easier worked, and the quality is superior or at least equal.

Algiers is not the only place where this measure can be adopted advantageously; it can be practised with advantage on the whole Mediterranean coast and wherever the puzzolana of Italy is used. The engineers of Toulon and Marseilles have already made arrangements for the importation of the sifted puzzolana, and there is little doubt but that it will become an extensive article of traffic.

The mortar is made with one part lime in paste, and two parts puzzolana. If the puzzolana is in the rough state the mortar becomes hard in four days and resists the Vicat rod; if it is sifted through the bolting cloths it will become hard in two days, and if the puzzolana is sifted through a fine hair sieve, it will become hard in twenty-four hours.

It takes six days for mortar to become hard, which is made of one part lime, one of bolted puzzolana and one of sand.

Béton is composed of one part mortar and two of stones broken to the size of from one to two inches,* making two parts of béton.

A cubic metre (35.317 cubic feet) of béton weighs 5886 pounds. It acquires in twenty-four hours, sufficient cohesion to withstand the shock of a heavy sea without disintegration. In November 1836, a block containing two hundred and fifty cubic yards, which had been immersed only thirty-six hours was stripped of its enclosure, and resisted the action of one of the most violent storms. M. Fénéon, a mining engineer, then at Algiers, was an eye witness of this remarkable fact.

The blocks made in the cases with cloth bottoms, measure generally from

* Whether cubic or superficial measure, is not stated. Tr.
VOL XXV.—No. 3.—MARCH, 1840. 16

sometimes to an insuperable obstacle to the use of loose stone, while the *béton* can be used any where.

The Romans drew blocks of stone from Mount Circe to build the port of Anxium, a distance of ten miles; and the pontifical government was obliged to abandon the port of Auzo in consequence of the difficulty of finding a quarry in the neighbourhood, that would furnish proper stone to repair the jetties.

The Italians generally practise a mixed system. They build the foundation of loose stones, even in twenty or thirty feet water, and the top of masonry. The masonry is constructed in staunch cases, floated to the place required, and the workmen, secure from water, erect a wall usually of undressed stone and hydraulic mortar. The cases are thus sunk by degrees until they reach the loose stone. The details of this process are described in Belidor's *Hydraulic Architecture*, in his description of the manner in which the moles at Nice, Genoa and Naples were constructed.

The defects of this plan are very apparent; the bottom of the case rests upon an uneven and movable surface, and the consequence is, the masonry cracks open in many places. Moles thus constructed are soon destroyed; extensive repairs are required, which make it necessary to be continually throwing in loose stone. This is exemplified in the mole at Genoa, which shelters the harbour from the east winds, the end of which constantly requires repair.

When De Cessart projected his large conical cases, he was on the eve of discovering the simple and ingenious plan just described for establishing foundations; the great error which was committed and which fully explained the difficulty encountered by so skilful an engineer, was in supposing that a wooden structure, however substantially constructed, could resist the action of the sea. Acting on this principle, he filled his cases with small stones to keep them in place; the consequence was that when the action of the sea beat these cases to pieces, the stones fell down and the whole fabric was swept away. De Cessart should have considered the case as simply a temporary enclosure to build masonry in, which would be capable of resisting the force acting against it after the cases were destroyed. If he had taken up this idea, it would probably have led him to the use of *béton* for filling his cases. Instead of making these cases as substantially as was proposed, it would be sufficient to give them the form of a large cask without a bottom, made with uprights and staves bound together by iron chains instead of hoops, in such manner that the uprights can be taken apart when the case is to be taken up. Another indispensable condition is, that the case should be filled in the shortest possible time. The sea at Algiers is very powerful considering the little range it has; and it would be necessary to make such arrangements that a case made to contain about 1300 cubic yards, should be filled in thirty-six, or forty-eight hours. This might be done by throwing in *béton* blocks, ready made, at the same time pouring in *béton* to bind them, by means of cloth funnels fixed to the cases. This suggestion has never been acted upon, but if the intention of making Algiers a military port be carried out, there will be an opportunity of trying it on a large scale, and it is believed with complete success.

Whatever may be the fate of this or other plans for using *béton*, one thing is certain, that sooner or later, the practice of making foundations at sea with loose stone will be entirely abandoned, and masses of the natural rock so costly in quarrying and transportation, and so insufficient in dimensions, will be replaced by artificial blocks made of *béton*.