Construction of the new bridge at Rochester, 1850--6

The civil engineer and architect's journal, Sat 17 May 1851, p 286

INSTITUTION OF CIVIL ENGINEERS.

May 13. -- William Cubitt, Esq., President, in the Chair.

The Paper read was "On the Pneumatic Method adopted in constructing the Foundations of the new Bridge arrow the Medway, at Rochester." By John Hughes, Assoc. Inst. C.E.

This bridge was described as being designed to consist of three large openings, a central one of 170 feet in width, and two others, each of 140 feet in width, spanned by cast-iron segmental girders, and of a passage to admit masted vessels to the upper parts of the river, across which a moveable bridge would be placed. Each of the river piers occupied an area of 1118 square feet, and rested upon a series of cast-iron cylinder piles, 7 feet in diameter, placed 9 feet apart longitudinally, and 10 feet transversely, so that there were fourteen under each pier. The cylinder piles in the abutments were 6 feet in diameter, of which the "Strood" abutment required thirty, and the "Rochester" abutment twelve. Each pile was composed of two, three, or more cylinders, 9 feet in length, bolted together through stout flanges; the bottom length had its lower edge bevilled, so as to facilitate the cutting through the ground. The bed of the river was originally presumed to consist of soft clay, sand, and gravel, overlying the chalk, and accordingly the application of Dr. Potts' pneumatic method for forcing the cylinder piles into the ground, which had been successfully carried out in similar positions, was contemplated; but after a few trials, the ground was found to consist of a compact mass of Kentish ragstone, so that the mere atmospheric action upon the piles, induced by a partial vacuum, would be ineffective in such a situation. It was therefore decided, that the pneumatic process should be reversed, so as to give each pile the character of a diving-bell; for which purpose one of the cylinders, 7 feet in diameter, and 9 feet in length had a wrought-iron cover securely bolted to it, through which two cast-iron chambers, D-shaped in plan, with a sectional area of about 6 square feet appropriately called "air locks," projected 2 ft. 6 in. above the top of the cylinder, and 3 ft. 9 in. below the cover. The top of each "air lock" was provided with a circular opening, 2 feet in diameter with a flap working on a horizontal hinge, and an iron door, 2 feet by 3 ft. 4 in. with vertical hinges below the cover; each air lock was also furnished with two sets of cocks, the one for forming a communication between the cylinders and the chamber, and other between the chamber and the atmosphere. Compressed air was supplied to the cylinder pile by a double-barrelled pump, 12 inches in diameter, and 18 inches stroke, driven by a 6-horse power non-condensing steam-engine. At first the expelled water was made to pass into the river, from beneath the lower edge of the piles, but when the stratum became so compact as to oppose a high degree of resistance to the passage of the air, an outlet was formed through the side of the uppermost cylinder, by the introduction of a pipe having the form of a syphon, the long leg of which reached to the bottom of the pile, and was subject to the pressure of the condensed air on the surface of the water within, whilst the short leg leading into the river, had the effect of relieving the amount of compression, provided a vacuum was once obtained in the body of the syphon. Such an effect was readily produced by connecting the summit with the exhaust side of the air pumps, by a pipe which could be opened, or closed, at pleasure.

To insure the downward motion of the pile, and to give it a weight which should be at all times superior to the upward pressure, two stout trussed timber beams were laid on the top of the cylinder, in a direction suitable for bringing the adjacent piles into action as counterbalance weights, by four chains passing over cast-iron sheaves.

Two light wrought-iron cranes were fixed inside the cylinder, the jibs of which swept over the space between the air locks and windlasses, inside and outside, for the purpose of hoisting the loaded buckets, and lowering the empty ones.

The method followed in working the apparatus was found to be so simple in detail, as to be perfectly intelligible to all the workmen employed. The pumps being set in motion, the flap of one of the air locks and the door of the other, were closed; a few strokes compressed the air within the pile sufficiently to seal the joints, and whilst the pumping was in progress, the men passed through the air locks to their respective stations. When the water was shallow, the pile descended, by scarcely sensible degrees, as fast as the excavation by hand permitted; when the water was deep, the excavation was carried down full 14 inches below the edge of the pile, which then descended, at once, through the whole space, as soon as the pressure was eased off.

The most perfect certainty and success had attended the employment of this simple system, and as it promised to afford considerable assistance to engineers in the prosecution of similar works, the author laid the account before the Institution with the sanction of Mr. Cubitt, President Inst. C.E., the engineer-in-chief, and Messrs. Fox, Henderson, and Co., the contractors for the works.

Times, Fri 27 Feb 1852, p 6

THE NEW BRIDGE AT ROCHESTER. -- Messrs. Fox, Henderson, and Co., yesterday invited the wardens of Rochester-bridge and a number of engineers and other gentlemen, to witness the arrangements for sinking, by means of the newly invented pneumatic process, the last of the cast-iron cylinders employed in the construction of the foundation of the new bridge over the Medway. After an examination of the finished portions of the work, the company witnessed with great interest the operations of expelling the water from the cylinder by means of atmospheric pressure, and of passing the workmen and materials in and out of the cylinder under pressure by means of what are technically called air locks, several of the gentlemen present entering, and remaining some time in the cylinder. The party consisted of Lord Darnley, Colonel Greene, director of Admiralty works; Colonel Sandham, R.E., Captain Simmons, R.E., Mr. Thomas Brassey, Mr. John Martin, M.P., Mr. Charles May, Dr. Fox, Dr. Black, and Mr. C. H. Wild, C.E., with Sir Charles Fox, one of the contractors of the bridge, Mr. John Hughes, superintendent of works, and Mr. John Wright, resident engineer, acting under Sir W. Cubitt, and about 30 other gentlemen, who, before returning to London, partook of a handsome lunch, prepared for the occasion at the Crown Hotel, Rochester.

Times, Mon 8 Mar 1852, p 8

... <intended reconstruction of Westminster bridge> ... No design has yet been adopted, but various plans have been proposed, among the number one founded on the system so successfully carried out by Mr. Hughes in the preparation of the foundations for the new bridge at Rochester. We lately had an opportunity of inspecting these works, and, as the mode of constructing these foundations appears not only admirably contrived, but particularly applicable to the repair or renewal of bridges in the metropolis, we propose to give a short description of the work. The bridge is to be carried over the Medway with three arches -- a central one of 170 feet, and an arch on either side of 140 feet span. The abutments and the piers (above low water-mark) will be built of stone and brick in the usual way, and the arches will be of cast iron. The roadway is designed to be 40 feet wide, and an opening bridge of 50 feet in width is to be made on the Strood side for the navigation of the Medway. During the season of the Great Exhibition the works in progress were visited by several of the first engineers of the Continent, and last Thursday the contractors, Messrs. Fox and Henderson, entertained a large party of eminent men, invited to witness the sinking of the last pile upon the plan devised to meet the unexpected exigencies of the occasion. The Strood-pier is completed up to a little above low water level, and can only be seen at that time of the tide. The foundation consists of massive cast iron bed plates, covered with concrete, resting upon a series of cast iron cylinder piles, sunk through the bed of the river into the chalk, 46 feet below the concreted surface. These piles stand about five feet above the bottom of the river, and are enclosed by a curtain of cast iron plates, serving to direct the flow of the current and to protect the piles from injury between ordinary and extreme low water level. This pier, as well as the other on the Rochester side, measures over the surface of the bed plates 70 feet between the points of the cutwaters, and 18 feet in width. The iron cylinder piles which support the bed plates are arranged in two rows of six in each and one pile at either end, carrying the points of the cutwater; they are 7 feet in diameter and are formed of cylindrical castings 9 feet long, bolted together in succession as the pile enters the ground. The stones, gravel, chalk, &c., are excavated and entirely removed from the interior of the piles, and a concrete of gravel and Portland cement is substituted when the pile has reached a stratum sufficiently hard to support the weight of the bridge.

To sink these piles 40 feet into the bed of the river, and to effect the excavation where, at low water of ordinary tides, there is 5 feet, and a rise of upwards of 20 feet at high tide, was, under the circumstances which presented themselves here, a problem of no common character. In suitable soils (and this was at first thought to be one of them) the vacuum method, which was patented by the late Dr. Potts, would assist in solving the qestion, if it did not succeed for the whole of the great depth of these foundations. An alternative presented itself of clearing the

piles from water, by means of powerful pumps, driven by steam-engines of from 12 to 20-horse power, and working out the excavation when the bottom was laid dry. Such was the method followed on a magnificent scale by Mr. Brunel with the greater part of the cylinder piles forming the supports for the remarkable bridge intended to carry the South Wales Railway across the Wye, at Chepstow; and such suggested itself as the resource to be called into action, after a few trials had proved Potts's method to be quite unavailable at Rochester. A careful examination of the ground forming the site of the Strood-pier, during a very extraordinary low tide, which occurred shortly after the attempts with the vacuum method had failed, and when measures were in progress for introducing water-pumps, brought out the fact, not previously known, that the bottom of the river there consisted of large rubble stones, intermixed with old but solid timber for a considerable depth, not less than six feet, as was then estimated, but which has proved to average 20 feet; and it became evident that any effort of pumping would cause a very large profitless outlay of money, and would result very much as would an attempt to make the surface of a sieve dry by withdrawing the water above it in the same way.

The principle of the diving-bell had been previously spoken of by many, in general and indefinite terms, as being probably useful in connexion with the system of iron cylinder piles; and it was now seriously discussed by the engineer and the contractors in all its forms, from the employment of divers in the helmet and caoutchouc dress to the use of the ordinary diving-bell, suspended inside the cylinder pile. It was sufficiently obvious that the cylinder pile itself might have the character of a diving-bell given to it by securely closing the top, and by forcing air into it until this had acquired a density sufficient to force out the column of water; but how to get the workmen into and out of a large iron vessel so closed up, how to carry off the stones, earth, &c., which had to be removed from its interior, and how to introduce the concrete and brickwork for filling it up, although equally obvious as conditions that must be satisfied (and satisfied, too, in a well ordered system to be carried into operation as any process usual in a properly regulated manufactory) were difficulties at first very imperfectly resolved.

Mr. John Hughes, as the engineer upon whom it devolved to devise and arrange the preliminary works and mechanical means for carrying out the contract which Fox, Henderson, & Co. had entered into, offered some suggestions to Sir W. Cubitt and to Sir C. Fox, which were favourably received, and they assigned to him the task of making the drawings and scheme complete, of constructing all the necessary apparatus, and of carrying it into operation. This duty he performed, and has described his contrivances in a paper read at the Institution of Civil Engineers last year. A technical account of the apparatus, which all who have seen it pronounce to be most ingenious, well considered, and effective, would be unsuited to our columns, and is already

recorded in the proceedings of the Institution of Civil Engineers; but we may quote the address of Professor Airy, when President of the British Association, at Ipswich in July last, as conveying a popular idea of it. -- The Astronomer Royal said -- "Considerable importance, however, is attached by engineers to some of the processes lately introduced, especially that of thrusting down an air-tight tube or elongated diving-bell, supplied with air at the proper pressure, by which men are enabled to perform any kind of work under water, in almost any circumstances, and in which men or materials may be transferred without disturbance of the apparatus by a contrivance bearing the same relation to air which a common canal-lock does to water."

That the working of this useful contrivance has been eminently successful may be judged by the fact that the 14 piles in the Strood-pier of Rochester-bridge have been excavated 40 feet into the bottom of the Medway, and this was done without regard to the period of the tide or of the day. The pressure of air in the pile averaged about 18 pounds per square inch, the maximum being nearly 26 pounds, or equivalent to a depth of 60 feet of water. In the Rochester-pier 13 of the piles have been completed to a depth of 22 feet in the bottom of the river, and the maximum pressure during the execution was about 15 pounds to the inch. At Chepstow two of the cylinder piles were sunk 48 feet below the bed of the river by Mr. Hughes's arrangement, under the direction of Mr. Brunel, the maximum pressure being 28 pounds to the inch.

After satisfying ourselves of the solid character of the completed platform for the Strood-pier, we crossed over to witness the sinking of the 14th pile for the Rochester-pier by means of the apparatus just noticed. This pile, standing on the bottom of the river, contained water to the same level inside as on the outside, which was 7 or 8 feet deep at the commencement of a flood tide. The air-pump, driven by a neat six-horse power portable steam-engine, being set to work, the pile was free from water in five minutes, the workmen then passed through the cages or air-locks and descended to the bottom of the river and proceeded with the excavation. Bucket after bucket was sent up through these air-locks until sufficient material had been cleared away to admit of the cylinder's further descent. The men were then recalled, the air let off, and, as the water rose, the cylinder, by its own weight, sank to a new footing. The process is thus repeated until the men have been enabled to carry the foundations to the necessary depth.

To say nothing of the complete safety under which the work can be carried on, and the small space of the waterway occupied during its progress, the advantages claimed for this system of foundations are their cheapness as compared with foundations formed by means of cofferdams, whether of timber or iron, and the security with which the superstructure can, without introducing timber piling, be raised on a bed of rock or of earth, known to be equal to the load it has to carry. ...

FOR THE REMAINDER OF THE NEWS, &c.

SEE THE SUPPLEMENT TO THE TIMES OF THIS DAY.

Daily News, Thu 14 Aug 1856, p 6

OPENING OF THE NEW IRON BRIDGE AT ROCHESTER.

ROCHESTER, Wednesday.

The large and massive iron bridge over the Medway, at this city, was formally opened to the public this afternoon, by the Bridge Wardens, the Earl of Romney and E. Twopenny, Esq.

The bridge, which is built of iron on granite piers, was commenced in 1850, the first pile having been driven on the 3rd of April in that year. The engineer is Sir W. Cubitt, and the contractors Messrs. Fox and Henderson. The foundations consist of iron cylinders, each nine feet in length, with a diameter of seven feet, each weighing about five tons. These cylinders were sunk to the required depth by means of great pressure, the water at the same time being kept out by compressed air. In many instances these cylinders had to be sunk forty feet below the bed of the river, until they reached the hard chalk, which afforded a firm basis. They were then filled with concrete. The series of cylinders are bolted together, and form two rows of six in each row for each pier, excepting that on the Strood side, where there are 30 cylinders. The courses of masonry commence at low water mark, and are carried upwards to 18 feet.

There are three arches to the bridge, the centre arch having a span of 170 feet, and each of the side arches 140 feet. The width of the bridge, from parapet to parapet, is forty feet, and including the approaches on the Strood side, its extreme length is 1,200 feet.

In consequence of the veto of the Admiralty it was necessary to construct a portion of the bridge as a swing, and this is looked upon as a triumph of engineering skill. This swing bridge gives a roadway of the same width as the rest of the bridge, and is 109 feet in length; the weight to be moved is 200 tons. The iron castings of the bridge, which are brought out by a judicious system of painting, are of excellent workmanship and finish. There is scarcely any sinking of the foundations perceptible, the only deflection being about one-eighth of an inch in the crown of the centre arch, derived from the cohesion of the parts. When the swing bridge is thrown open, which will be the case at stated periods, there will be a passage of a clear width of 50 feet for vessels to pass through. The old stone bridge over the Medway was completed in the year 1392, and has consequently stood nearly five centuries; it was built by Sir R. Knolles, and was kept in repair by contributions from the adjacent parishes. This bridge will be immediately taken down, and a large esplanade on the <>back of the Medway constructed with a portion of the materials. There was a grand display of fireworks in the

evening on the old bridge, and the after part of the day was observed as a general holiday in this city.

Morning Chronicle, Fri 15 Aug 1856, p 3

OPENING OF THE NEW BRIDGE AT ROCHESTER.

The large and massive iron bridge over the Medway at #Rochester, which has taken several years in its construction, having been completed,# was formally opened to the public on Wednesday afternoon. Precisely at three o'clock a procession consisting of the mayor (Mr. F. Farrell) and corporation, accompanied by the recorder, mace-bearers, and the other civic functionaries, proceeded from the Guildhall, dressed in their robes, and walked in procession, preceded by the band of the Chatham division of the Royal Marines, to the bridge-chamber, where they were met by the bridge-wardens and assistant-wardens, and the procession moved over the old bridge to the approaches of the new bridge on the Strood side. On the procession arriving at the new bridge they were received by the chief engineers, the contractors, and the other persons who have been engaged in its construction. The procession then slowly walked over the bridge, and on arriving at the middle of the centre arch, the Earl of Romney, as chief warden, declared the structure open for the full use of the public. A large number of ladies were admitted on the bridge to witness the ceremony. The procession afterwards moved on to the Corn Exchange, where a banquet was given to the wardens and assistant-wardens, the chair being occupied by the Mayor of Rochester, who was supported by the Earl of Romney, the Earl of Darnley, and several of the leading gentlemen of the city and county, to the number of nearly 200. The new bridge, which is built of iron on granite piers, was commenced in 1850, the first pile having been driven on the 3d of April in that year. The engineer selected for the erection of the structure was Sir W. Cubitt, and the contractors Messrs. Fox and Henderson, the iron work having been executed and cast by Messrs. Cockrane and Co., Woodside Iron Works, Dudley. The foundations consist of iron cylinders, each nine feet in length, with a diameter of seven feet, each weighing about five tons. These cylinders were sunk to the required depth by means of great pressure, the water at the same time being kept out by means of compressed air. In many instances these cylinders had to be sunk 40 feet below the bed of the river until they reached the hard chalk, which afforded a firm basis. The cylinders were then filled with concrete, forming a solid mass of two rows of six cylinders in each row for each pier, with the exception of that on the Strood side, where there are 30 cylinders. The courses of masonry commence at low water mark, and are carried 18 feet above low water. The bridge consists of three arches, the centre one of which has a span of 170 feet, and each of the side arches 140 feet. The width of the bridge

from parapet to parapet is 40 feet, and the extreme length including the approaches 1,200 feet. In consequence of the determination of the Admiralty it was necessary to construct a portion of the bridge as a swing, and this is looked upon as a triumph of engineering skill. This swing bridge gives a roadway of the same width as the rest of the bridge, and is 109 feet in length; the weight to be moved being 200 tons. When this portion of the bridge is thrown open there will be a clear width of 50 feet for vessels to pass through. The iron castings of the bridge, which are brought prominently out into view by a judicious system of painting, are of most beautiful workmanship and finish, and the design altogether at once grand and graceful. There is scarcely any sinking of the foundations perceptible, the only deflexion being about one-eighth of an inch in the crown of the centre arch, derived from the cohesion of the parts. The old stone bridge will be immediately removed, and an esplanade constructed out of a portion of the materials. This bridge was built in the year 1392. A grand and imposing display of fireworks took place on the old bridge in the evening.

Illustrated London News, (Sat) 16 Aug 1856, p 169

OPENING OF THE NEW BRIDGE AT ROCHESTER.

The large und massive iron bridge over the Medway at Rochester, which has taken several years in its construction, having been completed, was formally opened to the public on Wednesday afternoon. Precisely at three o'clock a procession, consisting of the Mayor (Mr. F. Farrell) and Corporation, accompanied by the Recorder, mace-bearers, and the other civic functionaries, proceeded from the Guildhall, dressed in their robes, and walked in procession, preceded by the band of the Chatham division of Royal Marines, to the bridge-chamber, where they were met by the bridge-wardens and assistant wardens, and the procession moved over the old bridge to the approaches of the new bridge, on the Strood side.
On arriving here the procession was received by the chief engineers, the contractors, and the other persons who have been engaged in the construction of the bridge. The procession then slowly walked over the bridge, and on arriving at the middle of the centre arch there was a discharge of artillery -- the Earl of Romney, as chief warden, declaring the structure open for the full use of the public. A large number of ladies were admitted on the bridge to witness the ceremony.
The procession afterwards moved on to the Corn Exchange, where a banquet was given to the wardens and assistant wardens the chair being occupied by the Mayor of Rochester, who was supported by the Earl of Romney, the Earl of Darnley, and several of the leading gentlemen of the city and county, to the number of nearly 200.

From one end to the other, on both sides, the bridge was decorated with flags, those of the city waving across the centre arch. During the ceremony of opening the bridge, Rochester Castle and its walls were covered with spectators. A grand display of fireworks took place on the old bridge in the evening.

The new bridge, built of iron on granite piers, was commenced in 1850, the first pile having been driven in that year. The engineer selected for the erection of the structure was Sir W. Cubitt, and the contractors Messrs.

Fox and Henderson; the ironwork having been executed and cast by Messrs. Cochrane and Co., Woodside Iron Works, Dudley. The foundations consist of iron cylinders, each nine feet in length, with a diameter of seven feet, each weighing about five tons. These cylinders were sunk to the required depth by means of great pressure, the water at the same time being kept out by means of compressed air. In many instances these cylinders had to be sunk forty feet below the bed of the river, until they reached the hard chalk, which afforded a firm basis. The cylinders were then filled with concrete, forming a solid mass of two rows, of six cylinders in each row, for each pier, with the exception of that on the Strood side, where there are thirty cylinders.

The superstructure, consisting of three cast-iron arches. two of 140 feet and one of 170 foot span, is a splendid specimen of the effects to be produced by modern engineering tools; -- all the joints of the massive castings of many tons weight each, are planed by machinery so as to fit with the accuracy of joiner's work: formerly a most tedious and costly process of chipping and filing these joints by hand, was adopted, or more commonly the rough castings were brought approximately together, and the space between filled in with iron cement. The weight of cast iron in the bridge is about 2450 tons. The swing-bridge, to allow of ships passing, is a remarkable structure, and is probably the largest work of the kind. The clear passage for ships is 50 feet, and the bridge spans the whole space, turning on a ring of iron of 30 feet diameter; the width is 40 feet, and the length 109 feet. The total weight is about 300 tons, yet this mass is moved readily by two men, who can open the bridge in five minutes. This bridge is for foot, horse, and carriage traffic.

We have engraved this bridge upon the next page, together with another iron bridge adjoining, which has been constructed for the East Kent Railway Company (Sir William Cubitt engineer). It consists of four parts. First, a swing-bridge with fifty feet span, on the Strood side, so as to allow the passage of masted vessels. Secondly, there is an opening a hundred and forty feet wide; then another a hundred and seventy feet wide; and, lastly, a fourth division equal to the second. The entire upper fabric is composed of iron, laid on handsome basements of masonry, and, including the piers, is nearly six hundred feet in length; the weight of metal in the girders alone being about seven hundred tons.

By way of contrasting the elegant fabrics of our times with the massive stone structure of a former age, we have also engraved the old bridge at Rochester, which will be immediately removed, and an esplanade constructed out of a portion of the materials. This bridge was built in the reign of Richard II. (1392), and is, we believe, with the exception of the triangular bridge at Croyland, the oldest structure of the kind in England. It has nine arches, is 550 feet long, and has a stone parapet and balustrades; the latter erected about a century since. The steep rise in the centre of the bridge, however, and its pointed arches, afford very distinct evidence of its great antiquity. The centre arch, like that of most old bridges, has a very much wider span than the others, and across this large arch there used to be a drawbridge, which, when raised, prevented the passage of the Medway. This drawbridge was removed about a century ago. There was, probably, a bridge at Rochester at a very early period; but there is no distinct mention of it till the time of Henry I., when it appears to have been of wood, a little above the site of which was built the stone bridge of 1392.

The approach to Rochester from the London side of the bridge is very striking. In our Views is shown in the distance the Norman keep of the Castle. one of the finest ruins of its period in the kingdom; whilst the cathedral forms an equally valuable study for the architect and anti-

quary, as a specimen of Early English.