February 7, 1865.

JOHN FOWLER, Vice-President,
in the Chair.

The following Candidates were balloted for, and duly elected :—
ALEXANDER BEATTIE, ZERAH COLBURN, WALTER ROBERT KINIPPLE, WILLIAM NETHERSOLE, DANIEL BADDELEY PRITCHARD, WILLIAM HUMFREY RANKIN, and JOHN RICHARD RAVENHILL, as Members; EMANUEL ALLEN, RICHARD AYLMER, CHARLES BARCLAY, JOHN HICKMAN BARNES, ALEXANDER RICHARDSON BINNIE, JAMES BRAND, WALTER BROCK, Captain RAFAEL CERERO, WALTER GIBBONS COX, HENRY ALLASON FLETCHER, JOHN HEAD, HENRY TEMPLE HUMPHREYS, ALEXANDER CARNEGIE KIRK, HENRY LEE, Jun., JOHN CHARLES LEWIS LOEFFLER, FREDERICK THORPE MAPPIN, JOSHUA LLEWELYN MORGAN, MATTHEW ANDREW MUIR, GEORGE GORDON PAGE, JOHN RICHARDSON, THEODORE ANTHONY ROCHUSSEN, HENRY ROSE, THOMAS VAUGHAN, WILLIAM STANLEY WHITWORTH, GEORGE WYTHES, and GEORGE EDWARD WYTHES, as Associates.

No. 1,123.—“The Chey-Air Bridge, Madras Railway.” By
EDWARD JOHNSTON, M. Inst. C.E.

THE River Chey-Air presents the usual features met with in nearly all the large rivers of Southern India. The banks are generally low, and ill defined, and the bed, for almost the entire width, and to an unknown depth, consists of clean sharp sand. For nine months during the year the bed is perfectly dry, being subject only to heavy floods in the months of May, June, and November, but, even during the driest seasons, the substratum is always highly charged with water to within 2 feet or 3 feet of the surface. This fact, added to the great depth of the sand, constituted the main difficulties to be overcome in constructing the foundations of this bridge.

The bridge is situated on the North-West Line of the Madras Railway, at a distance of one hundred and forty-three miles from the Madras terminal station. The extreme width of the river at the point of crossing is 3,320 feet from bank to bank, the drainage area being about 2,272 square miles, and the fall in the stream at the rate of 11 feet per mile. At a distance of twenty chains above the bridge, the river separates into two distinct channels, the

southern being the principal one, and at the point of crossing, it is about 1,600 feet in width; then the bank dividing the two channels occurs, between the 20th and the 21st piers, and has a width of 464 feet, and next the northern channel, 1,256 feet in width. The highest point of the bank in the channel is 5·57 feet above the bed of the river, and 2·27 feet above the general level of the land through which the line passes, for upwards of half a mile on each side of the river. As it was ascertained, that the highest known flood only covered the bank to a depth of 14 inches, it was decided to substitute an earthen embankment for a masonry viaduct on this portion of the work, and to span the Chey-Air, by two distinct bridges; that on the south consisting of twenty-two openings and that on the north having sixteen openings, each 70 feet span from centre to centre of the piers.

The piers were built of masonry laid on timber platforms, placed within dams, at a depth of 15 feet below the bed of the river, the water being pumped out during the progress of the work, by means of Piccotah pumps, placed around the dam, and worked as hereafter described.

In order to commence the work at the lowest possible level, the sand, over the site of the intended dam, was in the first instance removed, until the water was reached. Within this space the dimensions of the dam, 52 feet by 22 feet, were set out, when piles, 9 inches square, were driven at intervals of 10 feet, to a depth of 18 feet, the heads being cut off level with the water. The piles were secured by waling-pieces, and were strongly braced across. Close planking, $2\frac{1}{2}$ inches in thickness, was next let down behind the piles, and the space around was backed up with clay and grass sods, to prevent the sand from slipping in. Afterwards the Piccotah pumps were fixed at intervals of 3 feet along three sides of the dams, being supported on sleepers, bedded on clay, one end of each sleeper resting on the waling-pieces. About sixty men removed the sand within the dam with baskets, which were handed up as they were filled, to women and children, who carried it clear of the work: in this manner the excavation was proceeded with, until the required depth was reached, when the ground was carefully levelled, ready to receive the timber platform. Advantage was taken of the fall in the river, of 11 feet per mile, by cutting a channel from the dam, commencing at a depth of about 5 feet, and terminating on the surface, at a distance of 50 chains down the river, thus reducing the lift, from 15 feet to about 10 feet. As the excavation proceeded, the water in the dam was removed by thirty-six Piccotah pumps, which delivered the water raised by them into a wooden trough that surrounded the dam, whence it was conducted into the above-mentioned channel.

Plate 10, Fig. 1, exhibits the plan of a foundation, with the position of the Piccotah pumps, and wooden troughs for conveying away the water. Plate 10, Fig. 2, is a section, showing the Piccotah pumps fixed, the excavation and timber platform complete, with the masonry built upon the latter.

The Piccotah pump is much used in many parts of Southern India for irrigation purposes, and has been generally adopted by the Engineers of the Madras Railway for pumping out the water from foundations, for which it has been found to act in a satisfactory and efficient manner. It consists simply of a balance lever, one end of which is weighted by a man walking up and down the lever, while to the other end a bucket is suspended by a long bamboo; another man standing on a staging in the dam, guides the bucket, and fills and empties it. The bucket generally in use is 19 inches in diameter, and 12 inches in depth; it is made of thin sheet iron, with a curved bottom, and is capable of containing about 5 gallons. Two well-trained men will raise, on an average, about 35 gallons per minute, where the lift does not exceed 9 feet or 10 feet. At the Chey-Air Bridge it was found necessary to use at each dam thirty-six of these pumps, worked by a gang of seventy-two Coolies, who were relieved every six hours, and who raised, on an average, 1,260 gallons per minute, the mean lift being from 7 feet to 8 feet.

The timber platforms are entirely of aucha and eloopay, both close, hard-grained woods; and being placed at a depth of 15 feet below the bed of the river, where they are protected from the alternate action of air and water, it is believed they will be very durable. These platforms are 42 feet in length by 13 feet in width; the main beams and transverse pieces are 12 inches square, and are strongly scarfed and bolted together; over these there is a flooring of sleepers 10 feet long by 10 inches by 6 inches in section, spiked down with 12-inch jagged spikes. On this flooring, the masonry is constructed, in heavy courses of well-bedded stones, each varying in size from $\frac{1}{2}$ to $\frac{3}{4}$ of a cubic yard, built in hydraulic mortar and well grouted, to within 18 inches of the bed of the river, and therefore about 18 inches above the lowest level to which the water subsides in the sand, during the dry season. Above this point the fair work of the pier commences. Careful levels were taken during the progress of the works, but as the sand was exceedingly compact, no appreciable settlement took place after the first course of masonry was laid.

The piling and the timber around the dams have, in every instance, remained undisturbed; and the space between them and the masonry has been filled in with waste stone to a depth of 9 feet, in order to provide against the possibility of any scour

taking place during heavy floods. The works have withstood the monsoons of three years, without showing the slightest indication of any scour; in fact, after heavy floods, no alteration takes place in the bed of the river; and it was observed, that even the centre pegs for this bridge remained undisturbed for upwards of two years, previous to its construction.

The stone used for the foundations was obtained from a quarry of hard, slaty, magnesian limestone, and was raised in large blocks. The quarry was situated about 25 chains from the south abutment, and a communication with the works on the north side was effected, by means of a temporary railway, $1\frac{1}{4}$ mile in length, carried along the bed of the river, parallel to, and within 70 feet of the bridge. The stone from this quarry, as well as all other building material, was conveyed along this line to the works.

The upper part of the piers is built with a light-coloured magnesian limestone, obtained from a quarry situated $2\frac{1}{2}$ miles from the works, on the north side of the river. It was delivered on the works by a native contractor, at the rate of 5s. 6d. per cubic yard, subject to a deduction of $\frac{1}{4}$ th for bad stacking.

The total cost of preparing a single dam, with timber platform complete ready to receive the masonry, was:—

	£.	s.	d.
Pile-driving	24	3	6
Excavation	38	13	0
Pumping	50	2	0
Timber platform	37	9	0
Total	£150	7	6

The average number of workpeople, of all classes, engaged daily on the works, amounted to about 4,049, at the following rate of wages:—

310 stonemasons and stonecutters, from $7\frac{1}{2}d.$ to $1s. 3d.$ per day.	
80 carpenters	$7\frac{1}{2}d.$ „ $1s. 1\frac{1}{2}d.$ „
24 sawyers	$10\frac{1}{2}d.$ „ $1s. 1\frac{1}{2}d.$ „
15 blacksmiths	$10\frac{1}{2}d.$ „ $1s.$ „
15 hammermen	„ at $6d.$ „
15 bellows boys	„ $3d.$ „
340 Piccotah pump coolies	„ $9d.$ „
200 quarry coolies	„ $6d.$ „
1,100 coolies	from $3d.$ to $4\frac{1}{2}d.$ „
1,950 women and children	„ $1\frac{1}{2}d.$ „ $2\frac{1}{2}d.$ „

The Chey-Air Bridge contains 16,320 cubic yards of masonry, consisting of coursed work, quarry-faced, with chiselled-setting margin, and it was executed at a cost of £18,681. The works were commenced on the 13th of August, 1860, and were completed ready to receive the girders on the 16th of January, 1862,

thus occupying little more than sixteen months in their construction.

The character of the work yet remaining to be done, will be merely a repetition of what has already been executed in the case of several large bridges on the same line of railway. In illustration, the superstructure of the bridge over the River Cavery will be described, the spans being the same, and all the essential particulars very similar. The girders are continuous over two spans, and are thus 140 feet in length. They are ordinary boiler-plate girders, so proportioned as to give a maximum strain of 5 tons per square inch in the extended parts, and of 4 tons per square inch in the compressed parts. Each length of 140 feet is composed of three portions; the central one is 30 feet in length, and has its centre over the middle pier, while the two ends are each 55 feet in length, and extend to the centres of the two adjacent piers. The position of the joints was determined by calculation, as being at about the mean position of the points of contrary flexure, in various states of distribution of the load. The three pieces were connected together on a platform adjacent to the abutment; and when this was accomplished, the two girders were connected by cross bracing, and by a system of longitudinal bracing, formed of a 'herring-bone' arrangement of half timbers, bolted to the under side of the cross-bearers, by which the rails were carried. It was found, by experiment, that when the ordinary T-iron cross-bracing alone was fixed, the vibrations of a pair of girders could be increased to about 5 inches, by the application of a moderate lateral force isochronous with these vibrations; whilst on the addition of the herring-bone bracing, it became impossible to produce any appreciable vibration by such means. For the purpose of getting the girders into their places, at the top of each pier two frames were erected, each carrying two rollers in the lines of the centres of the girders. To the underside of the latter rails were attached, with their running faces downwards. The girders were first lifted, by jacks, from the platforms, when several rollers were fixed on the platforms, upon which they were let down. They were then hauled forward by a powerful crab tackle placed on one of the piers in advance, and so were ultimately taken to the further end of the bridge; the remainder being similarly hauled over in succession. Having thus always two bearing points, with the centre of gravity between them, there was no tendency to tilt, and no necessity for staging or scaffolding—a material advantage in the case of rivers subject to sudden floods of extreme violence.

The above description of the superstructure of the Cavery Bridge may stand for that of the Chey-Air, the girders for which are, with

some trifling variations of detail, made from the same designs, and the method of fixing which will be precisely similar.

This mode of bridging the larger rivers throughout the extent of the Madras Company's works has been found so certain and effectual, that scarcely any variation has been made from it since its original adoption in the case of the bridge over the River Palar, on the south-west line, about 100 miles from Madras, of the construction of which bridge the Author also had charge.

The communication is accompanied by three diagrams, from which Plate 10 has been compiled.

[Mr. J. M. HEPPEL

Fig. 1.

THE CHEY-AIR BRIDGE.
MADRAS RAILWAY.

PLATE 10 VOL. XXIV.

PLAN

Fig. 2.

SECTION

Scale.

0 1 2 3 4 5 6 7 8 9 10 20 30 feet.