

No. 666. "Account of the building of the 'Wellington' Bridge, over the river Aire, at Leeds."* By John Timperley.

'Wellington' Bridge at Leeds.

This bridge was erected from the designs, and under the direction, of the late John Rennie; it is situated on the line of road leading from Leeds towards Wortley and Armley, and spans the river Aire at a spot where it is 100 feet wide, and about 6 feet in depth; the banks rising to between 7 feet and 8 feet above the surface of the water.

The borings, which were made to the depth of 30 feet, on each shore, to prove the ground, previously to commencing the construction, showed the strata to consist of fine sand, and then sand and gravel, with thin layers of what was supposed to be stone, but was probably, hard concreted gravel, such as was afterwards found in excavating for the foundations. That on the south bank, was commenced in the middle of September, 1817. The upper part, for 6 feet or 7 feet in depth, was through fine soft sand; then came a bed of alluvial gravel, containing, at about 12 feet from the surface, black rotten wood, roots of trees, shells, bones, and horns of animals. The upper part of this gravel was coarse and open, but it gradually became finer and more compact, until it assumed the hardness of a concreted mass, resembling agglomerate, very like (except in colour) the Blackwall rock, which was taken up about forty years since, in deepening the entrance from the Thames to the East and West India Docks. Upon this stratum Mr. Rennie ordered the foundation to be placed, although it was not so deep by 4 feet, as he had originally intended.

The coffer-dam, which was formed of a double row of piles of half timbers, from 15 feet to 18 feet in length, was then completed; the best earth that could be procured for the puddle, was of so light a nature, that in high freshes the leakage became so considerable, as to render it advisable to allow the dam to fill with water, to prevent its blowing up. The details of the construction of this coffer-dam are given. It was kept dry by a steam-engine of 6 horses' power, which was fixed on the shore, and worked the pumps by an endless chain. The quantity of water was such as to keep the pumps constantly at work, night and day. The coffer-dam for the north bank was constructed after the foundations on the south shore were finished.

The details are then given of the sheet piling and wales, &c., in front of the abutments, which are each 30 feet long, by 28 feet wide, at the bottom, diminishing by offsets to 27 feet in length, by 21 feet in width, at the springing of the arch.

The abutments are built in radiating courses within, but on the

* The discussion of this paper was extended through part of the meetings of March 5th and 12th.

faces they are horizontal ; the stones were from 14 inches to 18 inches thick, cut correctly from templates, made to suit the respective courses. The lowest foundation courses were of large blocks, laid dry, and the joints well grouted ; but the other courses, up to the ordinary water-line, were laid in mortar, made from magnesian limestone, got on the banks of the Aire, a few miles above Ferry Bridge : the proportions were, one part of lime, one part of clean sharp river-sand, and one part of forge scale, the whole well mixed and tempered, and used quite hot. The grout was made from the same lime, and was used for all the courses, except the lowest, where Parker's cement was employed, which was also used for pointing all the face joints up as high as the water-level. In the other parts of the structure, the mortar was composed of one part of lime to two parts of sand, but that for the arch was made of equal proportions of lime and sand.

Great care is stated to have been taken with the joints, as no underpinning was allowed, the beds of the stones being all dressed to coincide accurately. The ordinary allowance was $\frac{1}{8}$ th inch for each joint, but on trying the first fourteen courses, from the springing, it was found, that 1 inch only was taken up by the joints, which gave $\frac{1}{14}$ th inch for each.

The stones were laid on the south side by a moveable crane, and on the north side from the end of the two-wheeled truck (somewhat resembling a timber-carriage) by which they were brought from the stone-yard on the south bank, along a wooden tramway and temporary bridge, extending from the south to the north shore, using either a simple sling, or sheave-blocks, for placing the stones, according to their dimensions and weight.

The construction, dimensions, and cost of this truck and of the crane are given in detail.

The abutments being finished, the piles were driven, to support the centres, which were fixed so high as to be above the freshes. The lagging was laid 5 inches higher than the proposed arch, to allow for its settlement. The six centres were framed of Memel pine, each rib containing about 370 cubic feet of timber.

The striking-wedges were of seasoned oak, well greased ; they were 6 inches wide and 9 inches in height altogether, the middle one, which was the largest, being the striking wedge. They were, however, found to be too narrow, for they were squeezed upwards of an inch into the timber, by the weight of the centres and the masonry.

Prior to framing the centres, one-half of the arch, which is a segment of a circle of 91 feet radius, with a versed sine of 15 feet, was laid down, full size, upon a platform, from which templates were made, for dressing the voussoirs and arch-stones ; the front voussoirs were 7 feet

on the bed, at the springing, diminishing to 4 feet at the crown; but the interior arch-stones, near the springing, were much wider. The arch-stones were, on an average, 3 feet long, by 18 inches thick. It was customary, in setting the stones, to saturate them with water; a thin coat of mortar was laid on the under stone, the upper one was lowered, and well beaten down while the mortar was soft; the surfaces were thus brought closely in contact with each other, and any interstices that remained, were grouted, after the vertical joints had been pointed with cement.

When the arch was turned to the extent of one-third from each side, about 20 tons of stones were piled on the crown, as an equipoise for the centres, and the haunches were not loaded until the key-stones were placed.

The turning of the arch occupied four weeks; when that was finished, the haunches were completed, and the centres were eased; but it was found that the weight, which before the arch was keyed was equal to 1000 tons, had forced the wedges into the timber, so as to render it necessary to cut some of them out, which occupied three days for the first easing. A second easing took place two days after, and after a third easing the centres were removed.

During the progress of the work, the arch squeezed down about $2\frac{1}{2}$ inches; in a few days after the centres were struck, it settled $1\frac{1}{2}$ inch, which increased slowly to $2\frac{1}{2}$ inches, after which no further subsidence was observed. The arch had thus arrived at the exact dimensions which were proposed by Mr. Rennie.

An account is then given of the progress of the remainder of the structure, the forming of the parapet, the roadway, the approaches, &c., the whole of which were finished on the 18th of June, 1819, having occupied thirty-three months in construction.

The stone used in the bridge, is a brown coarse sandstone, or mill-stone grit, of great durability, from the quarries at Bramley-fall, about four miles from the bridge; they were brought down by water to within 120 yards of the work. The price of the stone in the vessel alongside the work, scappled ready for dressing, was 9*d.* per cubic foot; the dressing and setting, exclusive of the cornice and the parapet, cost $4\frac{1}{2}$ *d.* per cubic foot, which, with conveyance and mortar, made in the whole 15*d.* per cubic foot; the cost of the cornice and parapet walls was about 4*d.* per cubic foot extra.

The total quantity of masonry was 80,000 cubic feet, and the entire cost of the bridge, including the toll-house, was £7530.

The paper is illustrated by three drawings (Nos. 3582 to 3584), showing the plan, elevation, and longitudinal and transverse sections of the bridge, with the details of the masonry and the centering.