

of water into them ; and, after a heavy rain, all the borings may be seen to yield water. This relieves the wall from the considerable pressure which would otherwise, in time, have caused its destruction.

In boring through the wall, it was found that the bricks, which had been placed in contact with the wet soil, had become soft and decayed ; but these bricks (or rather the portions of them brought out by the boring tool) were found to become hard again, when they had been exposed to the air for a few days.

Three portions of the wall were thus drained in March, 1843, by making three borings in each panel. The success of this first attempt was not quite apparent ; but Mr. R. Stephenson having approved of a further trial, with five borings in each panel, the result was so satisfactory that thirty more were thus drained, between October and December, 1843. These drains have therefore been more than a year in action ; and it is worth noticing that several of them yielded water freely throughout the drought of 1844. The good effect upon that portion of the wall is very plain ; though, since the mortar has been washed out in many places, it would hardly be expected that the success should be so complete as it is. This may be attributed to the borings having been made 16 feet deep inwards, and thus collecting the water before it reaches the wall.

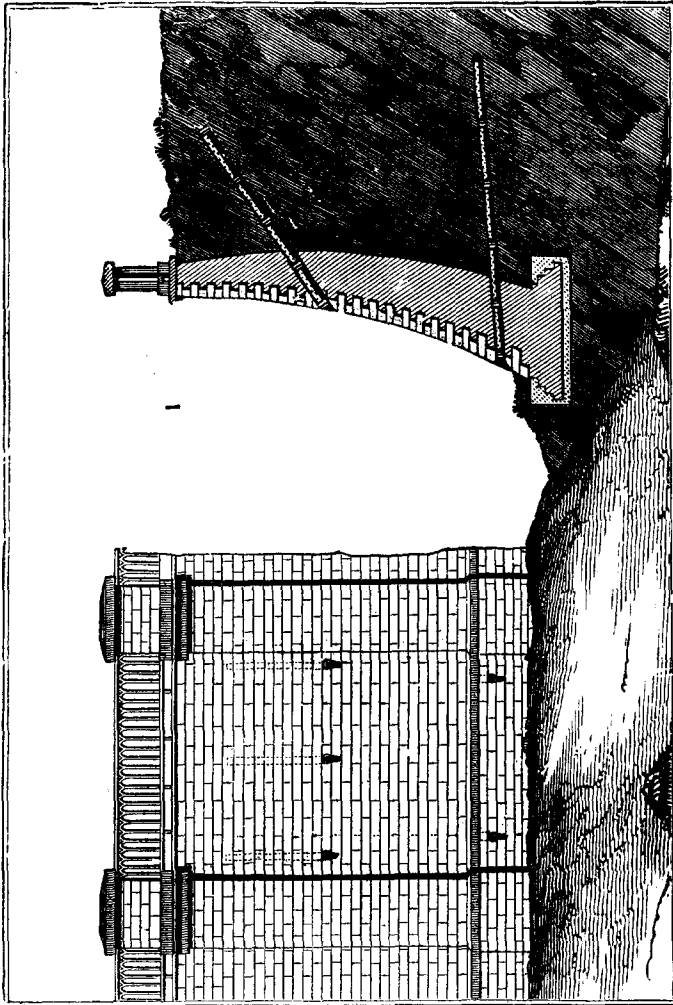
The panels operated upon in this way are 25 feet in height, and 20 feet in width. Each of them contains five borings ; but, in a more favourable soil, a less number would suffice. The charge for the work, including every expense, was 3*s.* 6*d.* per foot for the length of drain pipe inserted. The accompanying cut (Fig. 3) shows the position in which the pipes are inserted.

Upon the occasion of part of this wall being re-built, two panels had the drain pipes inserted during the erection (as shown in Fig. 4), and the result appears very satisfactory. In the retaining walls lately commenced on the Croydon Railway, they are being built in during the work. These are the iron-stone clay pipes. The author is of opinion that, in such cases, it is not safe to be content with merely building them in the wall, but they must also extend several feet behind it.

Mr. DOCKRAY said, that previous to the insertion of the drain pipes, the walls of the Euston incline appeared to be saturated with water ; but that they were now drying fast and the water no longer settled behind them, being discharged by the pipes as fast as it percolated through the backing.

The slope of the cutting near the Chalk Farm bridge showed a

Fig. 3.

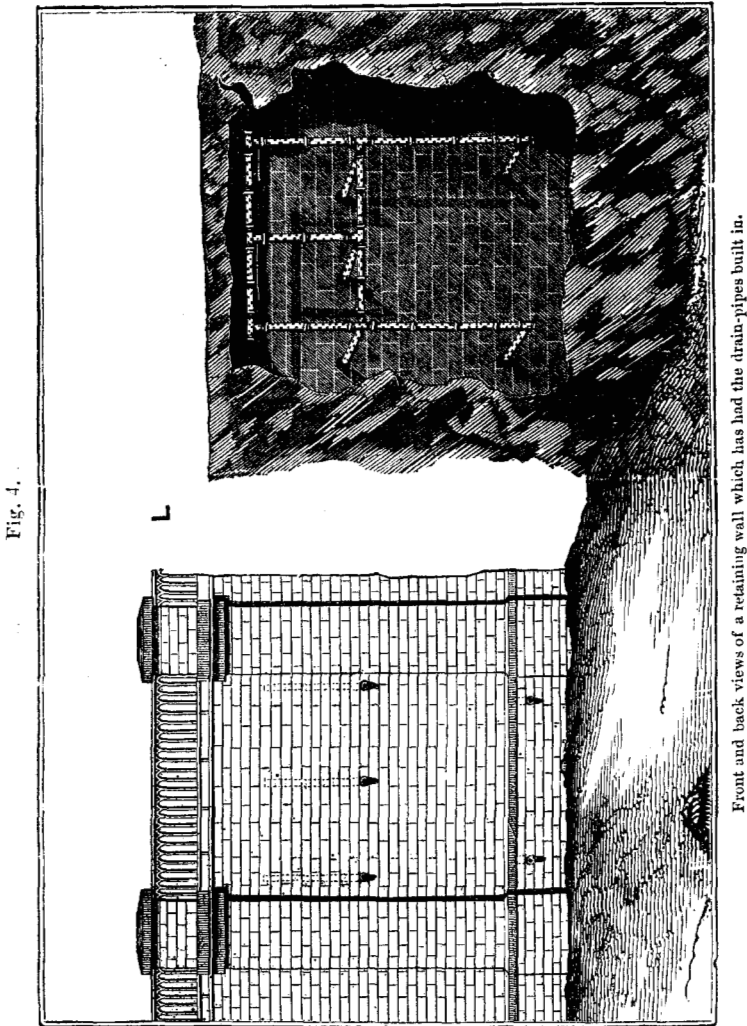


A cutting faced with brick-work.

tendency to slip, but the insertion of the pipes appeared, by draining the bank, to have stopped all movement of the soil.

Mr. R. STEPHENSON said, that the retaining walls of the Euston incline, were instructive examples of the discrepancy between theory and practice under peculiar circumstances. They were designed several years since, before he had attained his present experience of the effects of the action of the London clay.

The usual theory for the amount of pressure against retaining walls



was that of Prony,* which might be stated to be, that the pressure was equal to the weight of a prism of earth, slipping upon the face of the natural slope due to the character of the soil.

This theory held good as long as the soil was dry, but when it became, as in the London clay, saturated with water, the position

* Vide 'Architecture Hydraulique,' tome i., pp. 288, 289; also, Hutton's 'Mathematics,' prop. xlv., vol. ii., p. 201.

was no longer the same and the pressure was that due to a column of dense semifluid acting upon the back of the wall. In this particular case the inclination of the strata required to be considered, to account for what had occurred. The wall had been forced forward at the spot where, in plan, it formed a considerable curve, thus appearing to oppose the convex surface of the back of the wall to the pressure; while on the other side, where the back was concave, the wall did not stir. On examination it was found, that from the inclination of the strata, the water percolating through the fissures, accumulated against the convex back of the wall, reduced the clay to a semifluid state, and increasing its mobility, reducing the cohesion, until it forced forward the foot of the retaining wall, while the opposite wall, which would have been supposed to be weaker, remained firm; evidently because the inclination of the strata acted as natural drainage. The walls were 18 feet high, they were originally built 5 feet in thickness, but had been increased on rebuilding to 6 feet thick, and their foundations were sunk 5 feet deep below the surface, still they were forced bodily forward. It was natural to attribute the failure to the pressure of a dense semifluid, of a weight due to the altitude of the wall. The drain pipes had acted well in drawing off the water, but fearing that they might not prove sufficient in a long duration of wet weather, the cast iron truss beams were thrown across in order to lend the support of the lower and drier side to the upper side, which was more exposed to injury from the percolated water.

Mr. Stephenson thought that retaining walls should be built nearly parallel from the bottom upwards. That was the practice of the late Mr. Rennie, and was well exemplified in the walls of the Sheerness Dock. He allowed $\frac{1}{5}$ th of the height for the batter of the face and $\frac{1}{3}$ th for the thickness. Whether the thrust of the earth was opposed by a wall with a straight or a curved batter, an equally effective resistance was obtained, with a less quantity of material than in a wall with a vertical back and an inclined face; but the curved form was more convenient for dock walls and was more elegant in appearance. The whole question of retaining walls might be reduced to the simple mechanical principle of the lever and the inclined plane, indicated by the angle of repose of the soil, which the wall was intended to resist, due allowance being made for an increase of its natural density from the absorption of water.

Sir JOHN RENNIE, *President*, in reviewing shortly the interesting remarks of Mr. Stephenson, induced by the discussion, referred to some troublesome works executed by the late Mr. Rennie, on the old Croydon canal, where the London clay had caused many difficulties at that period, as it had done recently in the New Cross cutting of the'

railway. Mr. Rennie succeeded by carefully intersecting the crevices and by copious drainage, in diminishing the evil and preventing the extension of the slips. An elaborate report had been made on the subject which he promised to present to the Institution on a future occasion.

No. 709. "Description of the Ouse Bridge, on the Hull and Selby Railway." By William Brayley Bray, M. Inst. C.E.

In the year 1836 an Act was obtained for making a line of railway from Hull to Selby, where the proposed line was to join the line from Selby to Leeds, which had been opened two years previously.

These two lines now form a direct communication from Leeds to Hull, shorter by 29 miles than the old route by the Aire and Calder navigation, the Ouse, and the Humber.

Both lines were surveyed and executed under the direction of Messrs. Walker and Burges.

The Act contained a clause respecting the bridge, by which the railway was to cross the river Ouse, requiring an opening arch to be provided 44 feet in width, for the passage of steamers and vessels with fixed masts.

The river Ouse at Selby is about 196 feet wide, and 14 feet deep, at low water; the tide rises 4 feet at neap tides, and 9 feet at spring tides. The freshes are very rapid, and have occasionally risen 1 foot 3 inches above the high-water mark of spring tides.

At the times of the new and full moon, it is high-water at Selby about half-past 8 o'clock, $3\frac{1}{2}$ hours later than at Hull.

The bed of the river consists of silt, resting on a thin bed of quicksand, beneath which is hard clay. The clay dips to the north about 10 feet in the width of the river, and the south bank is so liable to slips, that in one part of Selby, the road along the side of the river cannot be raised within 3 feet of high-water mark spring tides; and on the site of the bridge, the kidding or staithing, formerly done to preserve the bank, had slipped many yards into the river.

The erection of the bridge was let to Mr. Briggs, of Ferry-on-Trent, and to the Butterley Iron Company. The work was commenced in the autumn of 1837. The piled foundations of the Selby abutment, and the adjoining pier, were finished early in the month of February following.

During the dry spring of 1838, the piles for the other piers of the north abutment were driven, and were finished in June; but the rain during the succeeding autumn and winter, caused such a continuance