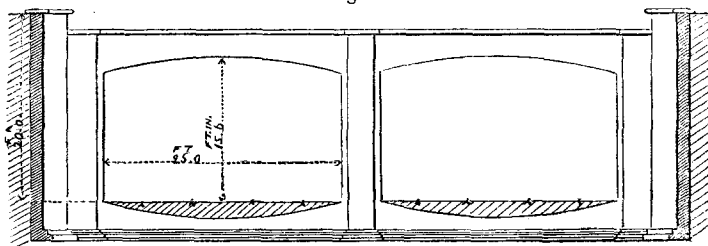


permanently effective constructions of the kind above described (Figs. 7 and 8), with central piers in continuation of those which already exist for the bridges and galleries, would require, in the same length, less than $10\frac{1}{2}$ rods, or about $\frac{1}{2}$ ths of the former quantity.

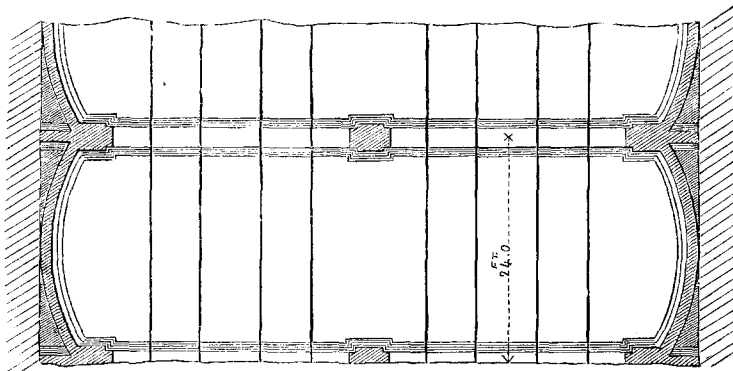
Fig. 7.



Application of the suggested Constructions to a Cutting similar to that for the Euston Incline.

SCALE.—1 inch to 20 feet.

Fig. 8.



Plan.

The paper is illustrated by six drawings (Nos. 3683 to 3688), showing the adaptation of the proposed constructions to various localities.

General Pasley stated, that the principle advocated by Professor Maj.-Gen. Hosking, had already been put into practice by Mr. A. J. Adie, in ^{Pasley.} the Chorley cutting, on the Bolton and Preston Railway.

The Chorley cutting was about 60 feet deep (Figs. 9, 10, and 11); it was cut through sand, which though dry at the summit, became wet and silty near the level of the forming. In the sand there existed large masses of clay which, after exposure to the weather, split from

the top to the bottom. Fearing lest an ordinary wall might be forced forwards by this expansive action, and wishing to avoid the expense of a very thick wall, Mr. Adie introduced a series of arches or struts, traversing the railway at intervals of 15 feet from centre to centre. These struts consisted of two arches of rubble and rough ashlar masonry, placed back to back (Figs. 9 & 11). The lower arch springing from the side walls, at a height of 11 feet 4 inches, and rising to 15 feet in the centre. The thickness of the arches at the centre, where they combined and were formed for some distance on either side, by the same stones, was 12 inches, with a course of rough flag stones laid upon the strut to keep the joints dry.

The retaining walls were 3 feet 9 inches thick at the bottom, vertical behind, but battering on the face to 2 feet in thickness at the top. The back

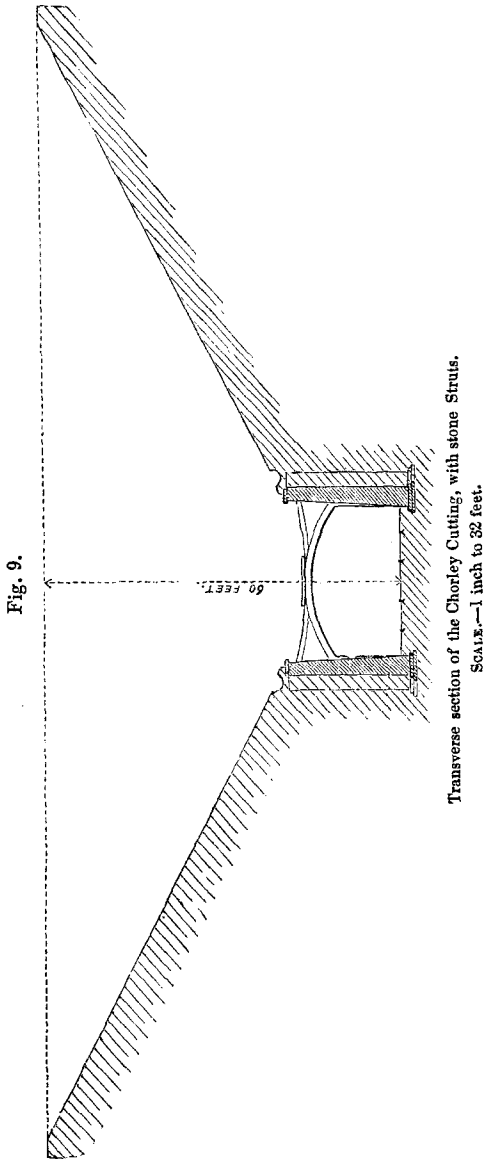
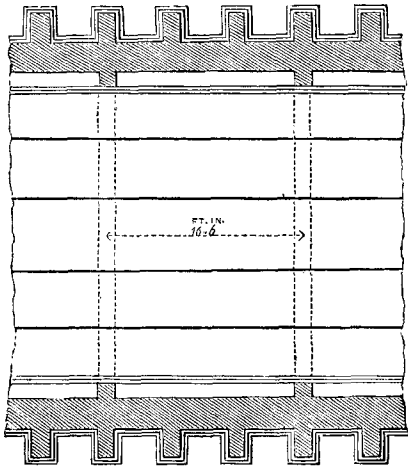


Fig. 9.

Transverse section of the Chorley Cutting, with stone Struts.
SCALE.—1 inch to 32 feet.

Fig. 10.



Plan of the Constructions in the Chorley Cutting.

SCALE.—1 inch to 16 feet.

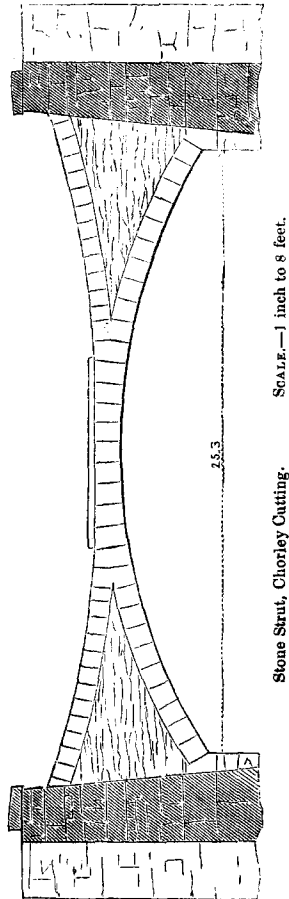
buttresses were parallel and projected 2 feet 6 inches. The walls were built upon a layer of engine cinders, which Mr. Adie preferred to concrete and which he had found of great assistance in constructions in wet situations.

Captain Vetch said he was sure, that Professor Hosking would be gratified to learn, that his view had been already tested by a successful experiment in a cutting near the village of Moseley, on the line of the Birmingham and Gloucester Railway. Captain Vetch.

The average depth of the cutting was about 30 feet, with firm gravel and dry sand at the top, which became wet below, and terminated in a quicksand at the level of the line of the railway.

The authorities of the place had the power of compelling the construction of a tunnel for a distance of about 200 yards; but it was deemed the cheaper plan, in such shallow ground and with a

Fig. 11.

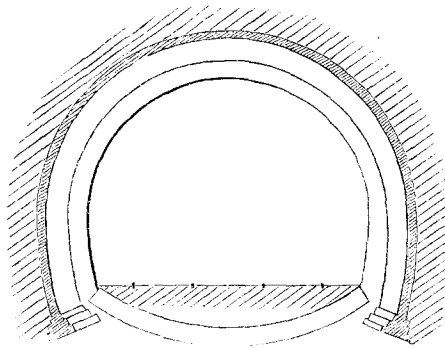


Stone Strut, Chorley Cutting. SCALE.—1 inch to 8 feet.

false foundation, to make an open cutting in the first place and afterwards to insert the brick-work of the tunnel, if required.

The cutting was accordingly made and the sides left rough and at as great an inclination as the nature of the ground would admit of; when the period approached for opening the railway, no definite arrangement about a tunnel having been made, it was deemed provident to be prepared for such a work; Captain Vetch consequently proposed to Captain Moorsom, the engineer and which met with his concurrence, that at every 15 feet, a rib, or inverted arch of brick-work (Figs. 12, 13, and 14), should be thrown across under

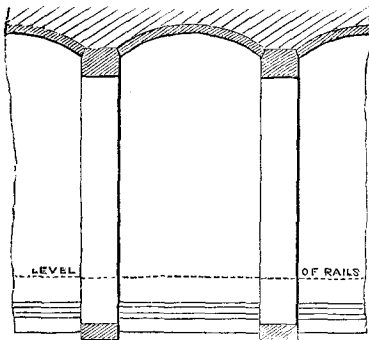
Fig. 12.



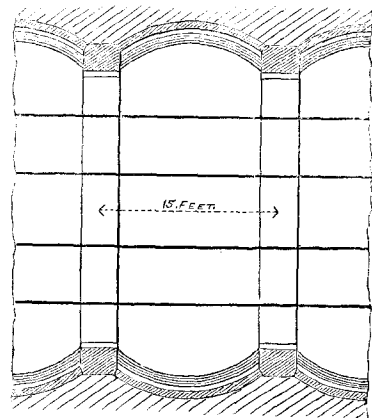
Moseley Tunnel.—Transverse section.

Fig. 14.

Fig. 13.



Moseley Tunnel.—Longitudinal section.



Moseley Tunnel.—Plan.

SCALE.—1 inch to 16 feet.

the railway and then to carry up, on the ends of these inverts, projecting buttresses with a curved batter; each pair of buttresses, on the same side of the way, to be connected by a concave retaining wall, abutting against them and each opposite pair of buttresses connected by mutual support by a flying buttress, thrown across and over the railway. This construction afforded complete security to the slopes and was executed at a moderate expense; it was, however, deemed prudent to conduct the concave side walls completely over the top and to make them abut on the flying buttresses, and so to form a complete tunnel at a very small expense; the buttresses, arches, and counter-arches, were all about $2\frac{1}{2}$ feet square and the concave walling and roofing were only 9 inches thick, but were backed with a little concrete. Captain Vetch thought the form adopted, afforded the means of doing the most work at the least expense, the extreme convexity of the coombs connecting the ribs, presenting a dome form of resistance, where the pressure was greatest, permitted the thickness to be much reduced. The latter portions of the work were executed in great haste, yet he understood, that the work had stood well and he thought it a cheap, as well as an effectual mode of supporting very weak ground, in railway cuttings.

Had the principle of ribs and projecting buttresses not been acted upon, it would have been necessary (from the wet bottom), to have laid down a continuous inverted arch, while the side walls and roof must have been constructed of much greater substance.

The form of the tunnel, when finished, approached to the form of a 'caterpillar,' and it was distinguished as the 'caterpillar' construction. Captain Vetch presented a drawing (No. 3689), showing in detail all parts of the construction.

Professor Hosking said, that he had no knowledge whatever of the existence of either of these instances, until they were mentioned by General Pasley and Captain Vetch. There could be no doubt but that they severally exhibited the leading features of his design and tended, jointly, to a practical justification of the suggestions he had made, as to the design and arrangement of retaining constructions. It seemed to him quite certain, however, that the profession generally was as ignorant as he was, of these instances, or that it had not yet been suggested how the peculiarities which they exhibited might be varied and combined, so as to produce better and cheaper retaining walls to the opposed sides of open cuttings, since common retaining walls and slopes continued to be made in such cases up to the present time without any suspicion, it would appear, of the means which he had suggested of constructing effective retaining walls more cheaply than slopes could be made.

Professor
Hosking.

Mr. Adie's were common retaining walls, with back counterforts at short intervals and the strut merely shortened the length of the unsupported work, but without any structural assistance to the intermediate portions and justifying but little reduction in the bulk of the constructions; whilst the strut itself, though probably quite sufficient for its duty, did not offer the resistance which vertically coursed work afforded. It was obvious, that the central portion of the strut, in Mr. Adie's example, was a part of the lower arch and that it might be thrown up by severe lateral pressure—and that the same pressure, would have a tendency to make the upper invert segments push up the tops of the walls, against which they abutted. He thought, therefore, that the peculiar composition of the strutting-beam which he had suggested, was essential to the full efficiency of which the arrangement was capable and which the strut must possess, in the more trying circumstances to which he exposed it. In Mr. Adie's example, the strut was merely auxiliary to the retaining walls; in Professor Hosking's design, it was an essential part of the system in which it was placed.

The constructions of the Moseley tunnel alluded to by Captain Vetch, exhibited the other essential peculiarity of Professor Hosking's design; but, singularly enough, the particular feature of buttress springing-walls and counter-arches, ceased where, according to his combination, they would have been of most value—that is, where the tunnel ceased, and the cutting commenced.

In a drifted tunnel, such constructions as those which were applied to form the Moseley tunnel, could hardly be executed and certainly not with economy—and they would not be applicable in an open cutting, because they depended wholly upon the weight of ground over head, to keep the crown from being thrown up, by the pressure of the ground upon the sides; they would require in effect, the straight abutment beam which had been suggested.

It was scarcely necessary to say, that the peculiarities of construction referred to in these remarks, had nothing in them of novelty, taken independently of each other and of the circumstances in which it was proposed to place them. The novelty consisted in strutting retaining walls, as Mr. Adie has strutted the walls in the Chorley cutting and in building buttress springing-walls to counter-arched lateral walls, as Captain Vetch had applied them in the Moseley tunnel—and all the merit Professor Hosking thought of claiming, was, for suggesting a combination of the two peculiarities in question, with such constructive arrangements, as might fit them for the important duty referred to, of retaining, securely and economically, the sides of deep cuttings, particularly in clays or other uncertain soils.