

“coursed rubble ;” but was of a very superior description, and in every respect similar to ashlar-work.

The author offers some remarks with regard to the expense of working tunnels by means of centre driftways. He states this plan to be costly, and in many instances without corresponding advantages, on account of the difficulty of keeping the road clear for the waggons. He recommends that when driftways are used they should be on the lower side of the dip of the strata, as the excavation would be facilitated, and the road would be kept clearer. In long tunnels he has found the cheapest and most expeditious mode of working to be by excavating the centre part from shafts, and both the ends (together if possible) from the extremities after the open cuttings are made. The drawing accompanying the paper gave a longitudinal section of all the tunnels, and showed to an enlarged scale several transverse sections of them, where the variations of the strata rendered either partial or entire lining necessary.

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In answer to questions from Mr. Vignoles and other members, Mr. Nixon. Mr. Nixon explained that the extra number of shafts had been required in order to enable the works to be completed within a given time: there had not been any accidents during his superintendence, but subsequently one of the shafts had collapsed. The cost of driving the driftways, the dimensions of which were 7 feet wide by 8 feet high, was ten guineas per yard lineal. He then described more fully his proposed plan of cutting the driftways on the lower side, instead of the centre of the tunnel, and stated the advantages chiefly to consist of a saving in labour and gunpowder, as a small charge sufficed to lift a considerable mass of rock when acting from the dip: the road was also less liable to be closed by the materials falling into it when the enlarged excavation proceeded from one side instead of upon both sides.

Dr. Buckland, after returning thanks for his election as an honorary member of the Institution, expressed his gratification at the prospect of a more intimate union between engineering and geology, which could not fail to be mutually beneficial, and cited examples of this useful co-operation in the cases of railway sections, and models that had recently been furnished by Engineers to the Museum of Economic Geology. Dr. Buckland.

He then proceeded to remark upon the geological features of the South-Western Coal-Field near Bristol and Bath, which had been described by Mr. Conybeare and himself, in the Transactions of the Geological Society of London (1824).

Some of the tunnels near Bristol are driven in the Pennant Grit of the coal formation, where it is thrown up at a considerable angle, and composed of strata yielding slabs and blocks of hard sandstone used extensively for pavement.

In traversing such inclined and dislocated strata, the engineer's attention should, he conceived, be especially directed to the original joints that intersect the beds nearly at right angles to their planes of stratification, and also to the fractures produced during the movements they have undergone. These natural divisions and partings render such inclined stratified rocks unworthy of confidence in the roof of any large tunnel, and liable to have masses suddenly detached.

Inclined strata of a similar sandstone are perforated by many tunnels on the railway near Liège, in nearly all of which the roofs are supported by brick arches.

It has been found impossible to make the tunnels through Lias and Red Marl without continuous arches of masonry.

In any of the tunnels which have been carried through strata of the great Oolite, the parts left unsupported by masonry would, in his opinion, be peculiarly liable to danger, because even the most compact beds of Oolite are intersected at irregular intervals by loose joints at right angles to the planes of the strata, and occasionally by open cracks; and it is to be feared that the vibration caused by the railway carriages would tend eventually to loosen and detach these masses of stone.

He apprehended still greater danger would exist in tunnels cut through the loosely jointed strata of chalk, unless they are lined throughout with strong masonry; and even that, in a recent case, had been burst through by the weight of the incumbent loose chalk coming suddenly upon the arch.

In open cuttings through chalk, where the numerous interstices and the absence of alternating clay-beds prevent any accumulation of water, there is little chance of such frequent landslips as occur where beds of stone, gravel, or sand rest on beds of clay; but until the side walls of chalk are reduced to a slope at which grass will grow, they will be subject to continual crumbling and the falling down of small fragments, severed by the continual expansion and contraction of the chalk, under the destructive force of atmospheric agents, and chiefly of frost.

In open cuttings, where the inclination of the strata is towards the line of rails, the slope should be made at a greater angle than if the strata inclined from the rails; if this be done, fewer landslips will occur from accumulations of water between the strata thus inclined

towards the rails; and such slips may be further guarded against by minute and careful observation of the nature of the individual strata, and a scientific application of subterranean drains at the contact of each permeable stratum with a subjacent bed of clay.

Tunnels can be safely formed without masonry in unstratified rocks of hard granite, porphyry, trap, &c., and in compact slate rocks; also in masses of tufa, such as cover Herculaneum, and are pierced by the grotto of Pausilippo near Naples: but, in his opinion, wide tunnels driven in stratified rock could not be considered secure unless they were supported by arches.

Mr. Sopwith confirmed the remarks on the importance to the Mr. Sopwith. Civil Engineer of a knowledge of the geological character of the strata through which tunnels or open cuttings were to be made: the cost was materially affected, as well as the stability of the works. The angle of inclination and the lines of cleavage should be carefully studied: on one side of a cutting the slope might be left steep, and all would be firm and dry; whilst on the other, if the same slope was adopted, all would appear disintegrated and wet, and a series of accidents would be the necessary consequence. He could not sufficiently urge the importance of a more intimate connexion between the Geologist and the Engineer.

In answer to a remark by Mr. Farey on the apparent advantages Mr. Bull. of Frazer's Centers for Tunnelling, Mr. Bull promised to procure for the Institution an account of the execution of some work with them.

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“An account of the Railroad constructing between Liège and Verviers, Belgium.” By Lieutenant Oldfield, Assoc. Inst. C. E.

The materials for this communication were drawn from the me- Railway between Liège and Verviers. moranda made during a tour by the author, who is an engineer officer in the service of the East India Company.

It describes the general course of the railway, descending by the long inclined planes, from the height above Liège to the valley of the Meuse, its progress along the banks of the Vesdre, through tunnels, and over almost innumerable bridges and viaducts, to Chaudfontaine, and thence onward through the town of Verviers, in the direction of Aix-la-Chapelle, to the frontiers of Germany. The modes of excavating the tunnels, and the materials used in the other works on the line, are accurately described; the general acclivities and curves of the road, the rails, chairs, and methods of fastening them to the sleepers, and the prices of labour and materials, are all given in detail, and the whole was illustrated by enlarged diagrams from the author's sketches.

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