

TUNNELING.

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TUNNELING is by no means a modern feat of engineering. In the early times the ancients resorted to it as a means of obtaining passage for their thoroughfares under their rivers, and also as a means toward drainage; but on the whole the operation was rather a crude piece of manipulating. That science has made great strides since those days, the instruments by which the great engineering obstacles can now be very quickly overcome, is but one of many illustrations. In the following paragraphs a few of the methods that are being followed in tunneling are briefly described.

Preliminary Surveys.—When it has been decided to tunnel in order to obtain a passage-way for railroads, electricity, waterpower, or whatever the case in question may be, we must have some idea of the obstacles which are to be overcome, such as the amount of material to be excavated; the nature of the material, whether loose gravel, rock or quick-sand, and also an idea of the surrounding country, as regards the necessary depth to rock, etc. A great many other data, which will be barely mentioned, must be gathered, and in order to obtain this a geological survey party is sent on to the field of operation. The information is obtained from the geologist's knowledge of the rock formation, and also from diamond drill borings, which are taken at intervals in the vicinity. Upon the rock formation depends the nature of the blasting, as it will be more efficient if the rock is attached perpendicularly to the stratification.

Generally speaking, a horizontal strata is very much weaker than a vertical strata, and, as a result, it needs heavier supports in the shape of tunnel lining, bracing, etc. Upon the geologist's report the character of the construction is to be based.

Centre Line of Tunnel.—Tunnels are divided into two classes—curvilinear and rectilinear. We will not follow the detail of curvilinear tunneling here, but will touch upon the rectilinear, as it affords a better discussion for a general treatise.

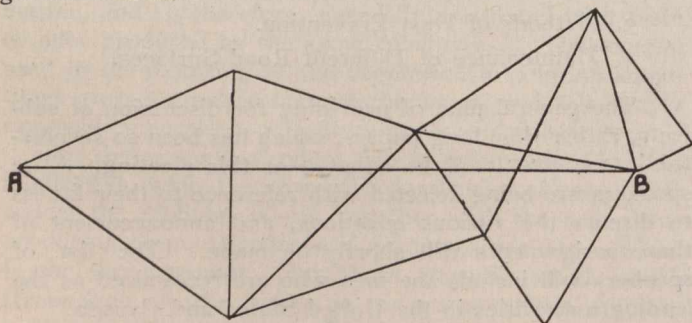


Fig. 1.

The centre line of a rectilinear tunnel is obtained by means of a triangulation survey. This must be carried on with the utmost accuracy. The angles and chainages must be read a number of times, and the results obtained by the method of least squares.

The triangulation method is illustrated very well by the above diagram shown in Fig. 1. It can be seen that the utmost accuracy can be obtained in this method of procedure. The line is staked out preliminary to the beginning of construction.

It might be said here that nearly all tunnels of any length are not worked completely from end to end, but have intermediate shafts by which the tunneling is carried on to much greater advantage.

The method of obtaining the line underground is illustrated in Fig. 2.

The depth is calculated from the profile of the tunnel. A-B is on the offset tunnel line. The plumb-bobs C and D give the direction of the line beneath the surface. A small tunnel is run to the main tunnel in question, giving a means by which the tunneling can be operated at this point.

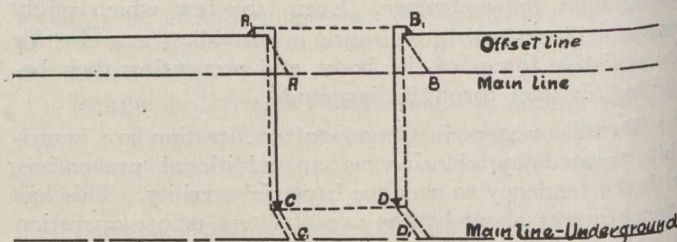


Fig. 2.

Different Methods of Tunneling.—The different methods of tunneling are in no way a small study by themselves. If we ponder for one moment over the subject we shall see the difficulty of preventing "cave-in" while the tunnel is under construction. This difficulty is off-set in a number of ways. Engineers of different nations have ways and means of their own, and from them are developed the methods by which every kind and condition of material may be encountered and successfully overcome.

We will see by the following how cleverly the methods are developed, and yet, after all, common sense is the one fundamental of them all. In fact, the basis of engineering is common sense and surveying.

Rock Tunnels.—Rock tunnels are carried through by the drift and the heading methods. The drift method is shown in the design by Fig. 3.

The parts 1, 2 and 3 are excavated, leaving supports 4 and 5, upon which is built the arch of the tunnel. At intervals along the side transverse cuts are made and filled in with the masonry. These support the arch after 4 and 5 have been cut away.

By Headings.—The more common method of rock tunneling is by the heading method.

Section I in the diagram (Fig. 4) is drilled through perhaps 200 feet to 300 feet in advance. Parts 2 are drilled into until finally we arrive at the point of constructing the arch structure. It is built up on the unexcavated rock below and is supported by 4 and 5, while fissure 3 is opened up. Parts 4 and 5 come next, and the lining is then inserted.

It might be interesting to mention the fact that rock tunnels do not require the heavy lining that is used in ground tunnels. This is very well understood on account of the fact that the rock walls are self-supporting, except where some crack or fissure allows the side to break off. These cracks and weakenings are caused by heavy blasting and also by the rock structure. If the strata is perpendicular to the side of the tunnel it will have greater tendency to cave-in than if the strata is parallel to the side. The St. Gothard tunnel is a very good example of the heading method of excavation. The tunnel was constructed in 1872-82, and is one of the longest tunnels at