

to be laid, and they then form a bond for the next length. Some prefer every length to be finished up squarely. It has a neater appearance, and is quite as strong as bonding one length into another.

A length should be complete in itself, and as one length is lined a few days before the next is commenced, there is time for settlement. If the bricks in this first length are tooth, the next, when built to it, settles also, tears out of the toothing, and becomes broken. This has to be patched, is unsightly, and suggests weakness.

Again, the courses may not be started at the same level as the last, and to get the bricks into the last toothing a little squeezing takes place, the consequence being that the first three or four bricks in every course of the new length are found to be running up or down out of the general level. A block toothing is best where bricks are used for lining. Stone side walls are another matter.

English bond is best for side walls. The first course of all wall footings may be laid dry, and the footings should have half brick projection every two courses in height. In heavy ground, however, portions of these footings are carried up plumb to formation level, i.e., full width of bottom course.

On these solid "stick-ups" set the sills and props for supporting the centre ribs. Before the wall is at rail level the courses must be level (except in the case of a gradient). At rail level leave a projecting brick near the leading end as a guide and reference. Now stretch a line from the saw cut in the wall frame, marking the courses to the corresponding course of the last length. Continue this procedure following the courses marked on the frame until springing level, the top of the frame, is attained. Grout every course and flush every joint. As the brickwork proceeds, all cavities between the back work and the mined ground must be carefully filled and packed solid.

The walls should be built up without interruption until complete to springing level, after which the centres or ribs are set. The ribs for a 5-yard length are, as mentioned before, three in number, viz., two intermediate and one leading.

The leading rib must be so placed that the laggings provided (15 ft. x 7½ in. x 2½ in.) will reach and fit between the groove or projecting sweep in the rib under the last toothing and on the one now being put up. Fix the ribs together by spiking pieces of plank upon their under sides, and drive up the slack-blocks until the crowns of the ribs are all level, and about 1 in. over sight to allow for after settlement in the work. All the necessary laggings required must be in readiness on the scaffolds standing under the last length.

One lagging is placed on each side at the arch-springing. The bricklayers put on lagging by lagging as they require them as the brickwork progresses.

The laggings will not bear on the ribs in places, when the latter have been used several times; in such cases it is necessary that wedges be used under the laggings, to keep them up to proper line, and to allow of no sagging or springing.

When the underside of the lower bar is reached, 2 laborers may then do the packing and help getting these bars out, which is done with the aid of tackle. To get a bar out it is raised a little, so that another course of brickwork can be got in to secure the ends of the poling boards that will be released by the bar. In heavy ground nearly all of the boards round the arch must be left in behind the brickwork to keep the ground from "running." When the ends of the boards are secured, the

bar can be lifted out of its place, and turned round until it can be got through a bay of the ribs, and back upon the scaffold under the last length. This is often hard work where many ribs are needed, and the nearer the crown the more crowded it becomes. For the arch, English bond for the brickwork is often insisted upon, while some prefer single-ring work, i.e., all bricks laid as stretchers with bonders of headers where possible, and which is good, securing better work and less mortar used. The more bricks and less mortar there are in such a piece of work, the better the work, providing there is enough mortar to properly bed the bricks. A ¼-in. joint on the soffit, if properly radiated from the centre, will be much thicker at the extrados of the brick, and must be so if the courses are to radiate. Care must be taken, so as not to overdo this, for if there is an excess, there will be a greater settlement afterwards, and in a wet tunnel the mortar gets washed out, reducing the safety of the arch.

Returning to lining the length, the arch is built up level with the top sill, when a bricking-in piece must be introduced. It has been shown that before the top sill could be got in the bars above it had to be back-propped ahead of it, as the brickwork cannot be built further forward than the sill, and as all bars must come out as drawn sooner or later. It follows that there must be a few feet of mined ground ahead of the toothing now being formed, poled with boards, but without support. When the bars are drawn out bricking-in pieces about 8 ft. 0 in. x 6 in. x 6 in., are placed behind the brickwork between each two bars, about 3 ft. of their length resting on the brickwork and the remaining portion projecting along the roof of the mined ground ahead. They are securely packed from the brickwork before the bar is taken out, and they will then hold up the poling boards and ground.

The seventh bars are the last taking out bars. Before getting up to this height, a temporary scaffold must be made above the main one.

When the bars are all out, bricking the arch continues under the drawing bars.

The last lagging which has been put on each side must be grooved on its top edge about 1 in. deep and the length of the lagging on which rest the block lagging, which are pieces of board 1 in. thick at the ends, 2 in. thick in the centre and about 3 ft. long, used for building the key. They are laid transversely to the other laggings.

At this stage the work is very arduous and comparatively slow progress is made. Generally speaking, 55 hours is an average time in which to line a 5-yard length. It can be done in about 42 hours, however, if a full gang is kept steadily on the work. This is, on the whole, rather uneconomical as when the brickwork approaches the key of the arch working space is badly curtailed. Better practice is to withdraw the gang of men on one side until the other side has finished up to the key or within about 1½ ft. of the crown. Then the other side is finished with greater ease and better workmanship.

The brickwork completed, the bars are drawn and operations continued on the next length.

After several hundred feet of tunnel is thus completed at any face, the centre drain should be built in. In size a drain 18 x 12 in. wide is generally sufficient. The bottom should be of 4-in. flag stone, and the sides of brick or flat bedded stone laid dry. A 6-in. flag stone bedded in mortar but with joints open forms a satis-