

Support and Reinforcement of Massive Rock

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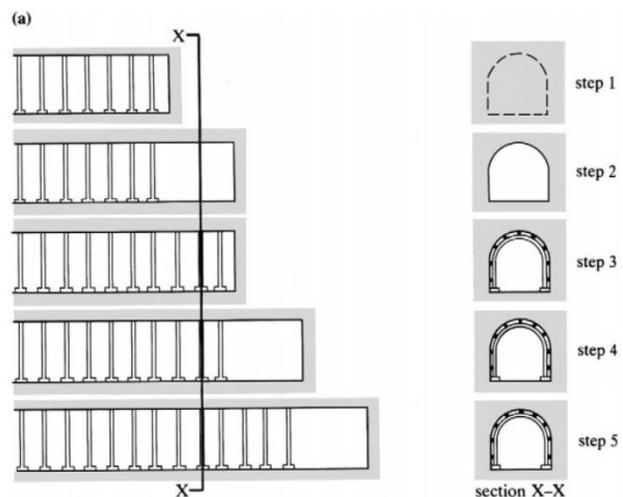
Ref. Book
Rock Mechanics for Underground Mining (3rd Edition)
B.H.G. Brady & E.T. Brown

Chapter-11

A heading is being advanced by conventional drill and blast methods. The pre-mining state of stress is assumed to be hydrostatic and of magnitude p_0 . Blocked steel sets are installed after each drill and blast cycle.

The following discussion concerns the development of radial displacement and radial support 'pressure' at a point on the excavation periphery at section X-X as the heading progressively advances to and beyond X-X.

In this discussion, the term support will be used throughout although the process involved may be one of support and reinforcement or reinforcement alone.

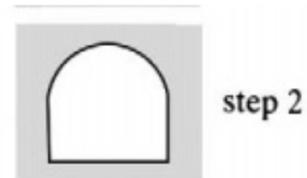
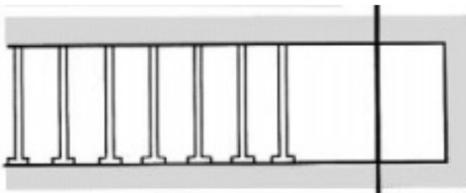


(a)



Following customary usage, the equivalent normal stress applied to the excavation periphery by the support system, will be termed the support pressure.

In step 1, the heading has not yet reached X–X and the rock mass on the periphery of the proposed profile is in equilibrium with an internal support pressure, p_i , acting equal and opposite to p_0 .



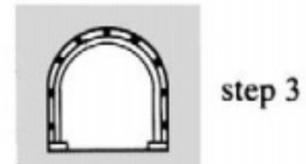
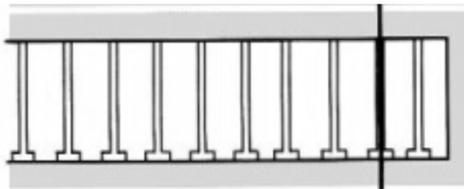
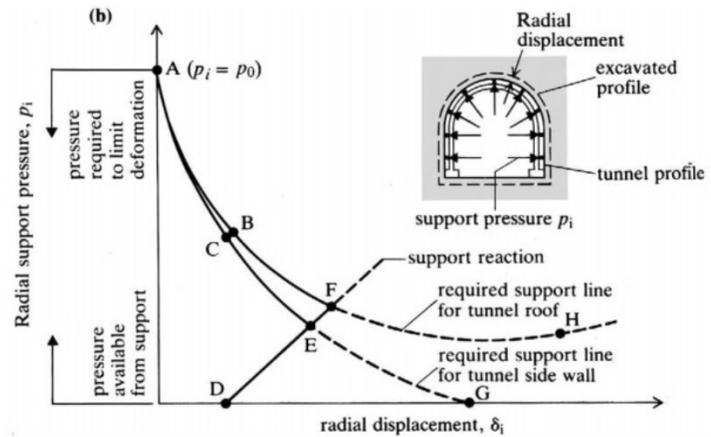
In step 2, the face has been advanced beyond X–X and the support pressure, p_i , previously provided by the rock inside the excavation periphery, has been reduced to zero.

However, the apparently unsupported section of the heading between the face and the last steel set installed, is constrained to some extent by the proximity of the face.

***In this case, the zone of influence of the face may be defined as 2.25 radii, at which distance from the face, the radial displacement is within approximately 5% of the comparable plane strain value.

The graph in Figure 11.1 shows a plot of the radial support pressure, p_i , required at a point to limit the radial boundary displacement, δ_i , to the value given by the abscissa. If the restraint provided by the face at step 2 were not available internal support pressures given by the ordinates of points B and C would be required to limit the displacements to their actual values.

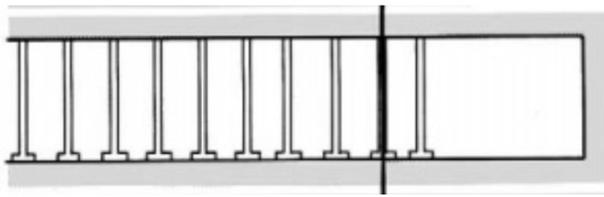
Different curves are shown for the side walls and for the roof. Extra support pressure is required to limit the displacement of the roof to a particular value because of the extra load imposed by the action of gravity on loosened rock in the roof.



By step 3, the heading has been mucked out and steel sets have been installed close to the face. At this stage, the sets carry no load because no deformation of the rock has occurred since their installation.

This assumes that the rock mass does not exhibit time-dependent stress-strain behaviour.

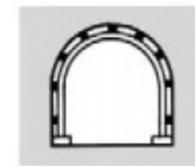
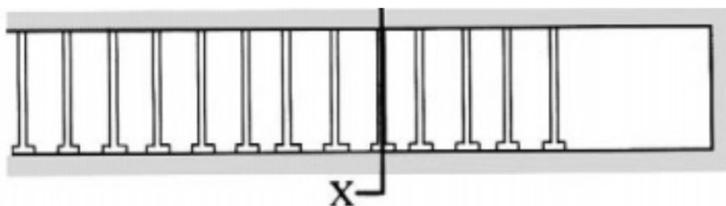
On the graph in Figure 11.1, the radial displacements of points in the roof and in the side wall, are still those given by points B and C.



step 4

In step 4, the heading is about one and a half tunnel diameters beyond X-X by drilling & blasting. The restraint offered by the proximity of the face is now negligible, and there is further radial displacement at X-X as indicated by the curves CEG and BFH in Figure 11.1.

This induces load in the steel sets which are assumed to show linear radial stress-displacement behaviour. Thus the supports typically load along a path such as DEF, known as the support reaction support line. The curve representing the behavior of rock mass is known as the ground characteristic or required support line. Equilibrium between the rock and the steel sets is reached at point E for the side wall and point F for the roof. It is important to note that most of the redistributed stress arising from creation of the excavation is carried by the rock and not by the steel sets.



step 5

section X-X

If steel sets had not been installed after the last two stages of heading advance, the radial displacements at X-X would have increased along the dashed curves EG and FH.

In the case of the side walls, equilibrium would have been reached at point G.

However, the support pressure required to limit displacement of the roof may drop to a minimum and then increase again as rock becomes loosened and has to be held up.

In this illustrative example, the roof would collapse if no support were provided.

(b) the radial support pressure–displacement curves for the rock mass and the support system (after Daemen, 1977).

