Quadrant II – Transcript and Related Materials

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Notes

GEOLOGICAL CONSIDERATIONS IN TUNNELLING

The convenience and cost of tunnelling as well as the safety and stability of a tunnel depend, to a considerable extent on

1. The nature of the rocks, which occur along the course of the tunnel.
2. The geological structure of the rocks.

1. **NATURE OF ROCKS**:-
   A) Hard and crystalline rocks:

   Crystalline rocks of igneous origin are most favorable for tunnel and can be excavated by using conventional rock blasting methods and also by tunnel boring machines of suitable strength. The cost of tunneling through rocks of this type is naturally, rather high, but this extra cost is compensated in another form, since such tunnels normally do not require protective inner lining for their safety and stability.

   B) Soft rocks: This group includes shale poorly compacted sandstone, porous limestone and dolomite, slate and phyllite with high degree of cleavage and also decomposed varieties of igneous rocks. These rocks can be excavated very easily, but such tunnels always require a sufficiently strong inner lining for their safety and stability.

   C) **Fissured rocks**:

   Any type of hard and soft rock that has been deformed due to secondary fracturing or faulting are always hazardous. Some volcanic rocks like basalt, rhyolite, trachyte, etc are hard and tough and at the same time, contain joints and vesicles filled up with water or secondary minerals. Tunneling through such rocks is therefore generally hazardous.

Tunnels through crushed and fragmented rocks must be protected by means of a suitable lining.

GEOLOGICAL STRUCTURES

The design, stability and cost of tunnel depend not only on the type of rock but also on the structures developed in these rocks.

The main structural features are dip and strike, folding, faulting, shear zones and joints.

DIP AND STRIKE: These two quantitative properties of rocks determine the attitude of rocks and hence influence the design of tunnel to a great extent. Three general cases may be considered.

1) **HORIZONTAL STRATA:**

Horizontally layered rocks might be considered quite favourable. In massive rocks, that is when individual layer is very thick, and the tunnel diameter is not very large, the situation is especially favourable because the layer would then over bridge flat excavation by acting like a natural beam. But when the layers are thin and fractured, they cannot be dependent upon as beams. In such cases, either the roof has to be modified to an arch type or has to be protected by giving a lining.

2) **MODERATELY INCLINED STRATA** :

a) **Tunnel axis parallel to the dip direction:-**

The beds offer a uniformly distributed load on the excavation. The arch action where the rocks at the roof act as natural arch, transferring the load on the sides. Even relatively weaker rocks might act as self supporting in such cases. However, the axis of the tunnel has to pass through a number of rocks. This is undesirable because in such a case the tunnelling conditions differ from place to place and this may lead to problem like instability and over break.

b) **Tunnel axis parallel to the strike :-**

The pressure distributed to the exposed layers is asymmetrical along the periphery of the tunnel opening as one half would have bedding planes opening into the tunnel and offer potential planes and conditions for sliding into the opening. The bridge action though present in part, is weakened due to discontinuities at the bedding planes running along the arch.

3) **STEEPLY INCLINED OR VERTICAL STRATA:**

a) **Tunnel axis parallel to the dip** :-

When the tunnel axis is parallel to the dip direction, the formations stand along the sides and on the roof of the tunnel. An apparently favourable condition provided all the formations are sound.

b) **Tunnel axis parallel to the strike :-**

In tunnels running parallel to the strike of beds, it is more than likely that a number of bedding planes are intersected at the roof and along the arch so that natural beam action or arch action gets considerably weakened.

4) **FOLDING**

Folds represent the deformation of rocks under the influence of tectonic forces. Hence the folded rocks will be under considerable strain. When excavations for a tunnel are made in folded rocks, such rocks get the opportunity to release this strain. Such a release may occur in the form of rock burst or rock fall or bulging of the sides or the floors or the roof. In folded regions, the tunnel alignment may be parallel or perpendicular or oblique to the axis of the folds. Further, the tunnel may run along the crest or trough of limbs.

a) Tunnel along the limbs, parallel to the axis of a fold :-

This is desirable because similar formations with similar physical properties and physical conditions are encountered along the course of the tunnel.

b) Tunnel along crest, parallel to the fold axis:-

Along the crest, the rock masses may be in a highly fractured condition. As a consequence of this, if a tunnel is driven in such a place, there may be a frequent fall of rocks from the roof. But at the anticlinal core, joints are developed perpendicular to the bedding planes and wedge shaped blocks are produced. These wedge shaped blocks acts as a keystone and they prevent the fall of adjacent rock masses.

c)Tunnels along troughs, parallel to the fold axis:-

Tunnels along troughs encounter unfavorable conditions. The joints converge upwards so that the blocks bound by joint planes are liable to fall down into the tunnel. Further the inclination of the bedding planes may guide the percolated water towards the trough and create undesirable groundwater problems.

d) Tunnel alignment perpendicular to the fold axis:-

This is undesirable because under such a condition, different rock formations are encountered from place to place along the length of the tunnel and also the tunnel has to pass through a series of anticlines and synclines. These two factors bring about heterogeneity in physical properties of rocks. There will be a serious problem of seepage and fallouts through out the tunnel.

5) **FAULTING**

Faults are the surfaces along which rock movement has occurred in the past. These are also potential surfaces for future movements of the rocks. Similarly, fault zones and shear zones are highly permeable zones, likely to form passages for groundwater. Therefore it is necessary that, wherever tunnel is intersected by a fault plane or shear zones, it should be provided by maximum support and drainage facilities.

6) **JOINTS**

Joints are the planes of weaknesses. Closely spaced joints in all kinds of rocks are harmful as it may lead to over break which is undesirable. Another problem that is likely to crop up due to joints is the groundwater problem. It may, however, be necessary to protect these weak zones by means of a suitable lining within the tunnel.