GEOLOGY SEMESTER IV

GT 403 – ENGINEERING GEOLOGY AND ENVIRONMENTAL GEOLOGY

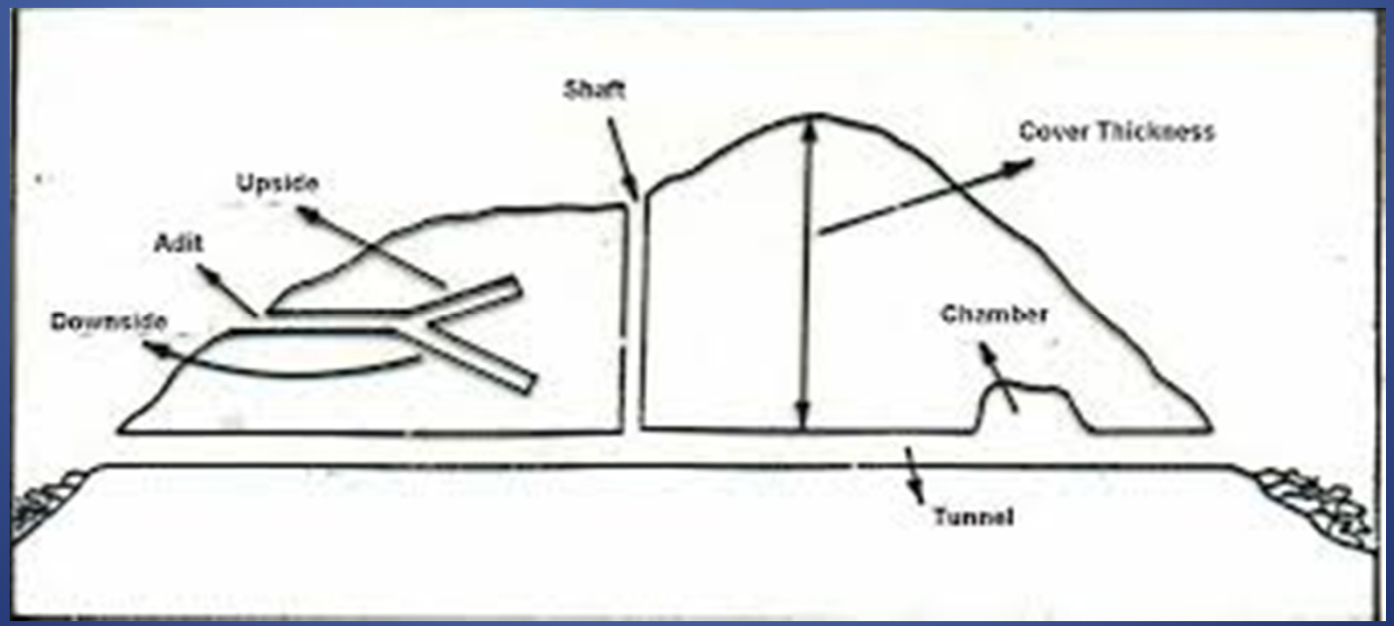
Topic – GEOLOGICAL HAZARDS IN TUNNELLING

Source :

- Peter T. Bobrowsky_ Brian Marker - Encyclopedia of Engineering Geology-Springer International Publishing (2018)
- Subinoy-Gangopadhyay- Engineering Geology, first edition,(2013)

Introduction

- In India different types of tunnels were constructed in various parts of the country. Geological problems faced during tunneling through several rock types or unconsolidated materials were many. A description of the main problems is discussed below:

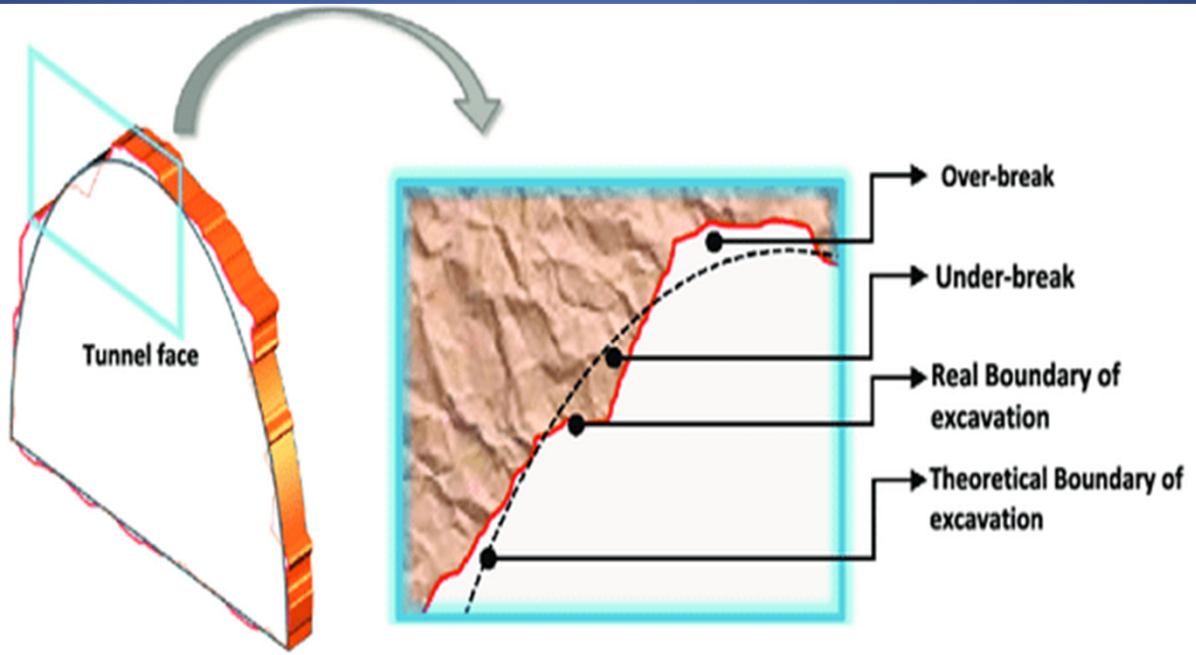


Geological Problems Due to Tunneling with Indian Examples

The hazards encountered in the construction of a tunnel are not related to the type of the ground but depends on the geological conditions of the rocks or unconsolidated material of the ground through which the tunnel passes. The following are the problems generally encountered during tunnel construction:

- Overbreak including chimney formation and wall collapse
- Spalling of tunnel rock
- Flowing ground
- Squeezing and heaving ground
- Temperature rise with presence of thermal spring
- Gas flow
- Seismic effect

- Overbreak



It is by far the major type of hazard in tunnel construction.

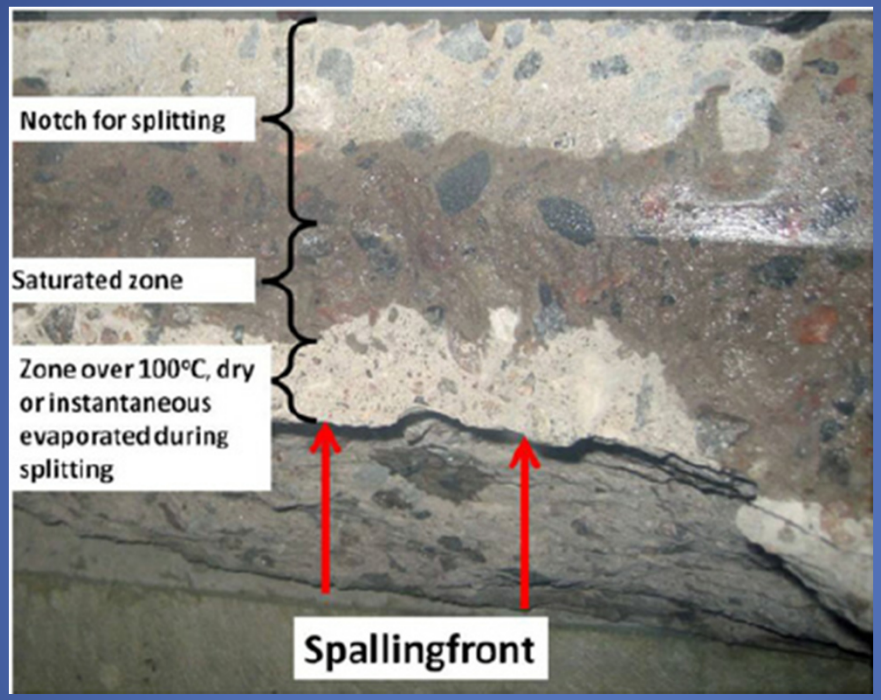
It results when the tunnel pierces through soft rock or extensively jointed rocks. The chances of overbreak are more in fractured rock affected by tectonic movement. In the sedimentary rocks where the rocks are layered and alternated with hard and soft bands, overbreak is more prolific due to differential strength of the rocks and their attitude or configuration of the beds.

In homogeneous rock free from fractures, the problem is less, but highly micaceous metamorphic rocks due to their less strength and more fragility (with high foliation character) are responsible for more overbreaks.

Folding and faulting result in deformation and shattering of rocks. If a tunnel cuts across a fault or shear zone, it may cause serious overbreak deep inside the crown appearing like a *chimney* .

Wall collapse is a very common feature in many of the tunnels. This is caused mostly by unfavorable structure of tunneling media. If the tunnel is aligned parallel to the strike of beds or foliation planes, the problem of collapse of wall rock including a part of the roof becomes more acute. This problem was frequently experienced when tunneling through the tectonically disturbed rocks of the Himalayan terrain.

- Spalling



It is the process of splitting of layers of rock from the tunnel wall and roof under saturation with water for a prolonged period and undergoing some chemical reaction.

The sedimentary tuff is made of argillaceous as well as arenaceous (sandy) materials, the shaley matter being 55 per cent in the tuff. The slaking characteristics of these matters may cause spalling and squeezing of the incompetent members after excavation of tunnel.

The slaking characters can be known by collecting samples from surface and drill cores and testing in the laboratory. Heavy supporting is required to arrest tunnel rocks affected by spalling.

Spalling conditions in strong quartzite and squeezing ground condition in softer phyllite rock were experienced in the Dul Hasti tunnel in Jammu and Kashmir.

- Flowing ground

Groundwater inflows during tunneling

Flowing ground condition inside a tunnel is a very adverse geological situation. Such a situation arises when entrapped water under hydraulic head gushes out immediately after tunneling. During rainy season, this problem may become serious with large flow of water through porous rock with water table above the tunnel level.

The problem is aggravated when large quantities of silt and clay flow out from tunnel rocks with the water and deposit the load to choke a part of the tunnel. It creates a situation of repeated mucking, aggravating and delaying the tunneling work. Since natural arching cannot be formed in loose material under flowing condition, the removal of muck will lead to further problems.

In sedimentary rocks, some thin beds or pockets of loose porous sandstone may cause such problem of flowing ground.

The approach to tackle the situation would be to allow the muck to flow out of cavity, if required by a small diameter subsidiary tunnel, and to reduce the water pressure by maximum drainage. Refrigeration of the impounded water is a good technique to arrest the flow but is yet to be applied in our country.

- Squeezing and heaving

Squeezing and heaving ground condition is encountered when tunneling is done in unconsolidated rock or clay stone containing deleterious clay minerals. When soaked with water, the montmorillonite in such soft clay band or unconsolidated material develop swelling pressure, and a portion of the tunnel wall or roof may squeeze or heave away making it difficult for tunneling.

The *squeezing ground* condition is prevented by immediately covering the entire stretch by shotcreting and then providing steel rib supports capable of holding the distributed load. The cumulative tunnel support required is governed by the designed stress computed from instrumentation. The use of yielding support is necessary to tackle conditions of squeezing ground.

Severe squeezing and heaving was observed in Loktak tunnel in Manipur while driving through shales. Steel supports were twisted and tunnel diameter reduced due to squeezing. Heaving of floor was also equally heavy. Rock bolts and shotcreting were adopted to tackle such adverse geological conditions

- Thermal springs

Thermal springs may be met in some hilly terrain during rock tunneling through very deep parts. This may cause rushing of hot water inside the tunnel leading to problems in tunneling. There will be a temperature increase in the deeper parts of underground, and the heat may be prohibitive for excavation work.

In the Kolar gold field, when underground mining is continued below a depth of 4 km, the *popping action* (shooting of rock fragments under pressure) is frequently encountered. The temperature is so high at that depth that excavation could proceed only after providing air-conditioning facility.

- ## Gas flow

Gas flow is encountered in many tunnels of the world, especially in mining tunnels.

Suffocating gas generated from blasting in the absence of proper ventilation arrangement may hamper the working in the tunnel. At times, during tunnel boring, there is an accumulation of poisonous gas from some organic sources such as the peaty bogs or swamps close to tunnel line.

One such gas is methane (marsh gas), which is inflammable and causes danger to workers by igniting into flame as observed in coal mines but is generally exhausted quickly. Such hazards can be avoided by providing proper ventilation arrangements to divert the gas to surface by pipes and blowers.

Loktak project of north-eastern India during tunnel construction experienced natural gas flow through the pores of shale from a part of the tunnel, which was, however, stopped within a short time.

- Seismic effect

Seismic effect causes serous hazards to tunnels. The intensity of earthquakes that occurred in an area in the past needs to be known to suggest future possibility of ground movement affecting the tunnel. Seismic zoning map gives the status of earthquakes experienced in different parts of India.

The most vulnerable area is the Himalayan terrain where several faults and thrusts are present. Movement of ground along these planes of tectonic activity due to stress relief may trigger earthquakes.

Most of the major earthquakes in India such as that of Bhuj, Gujarat, in 2001 are generated by the movement of Indian plate. Even peninsular India, which was so long considered to be a stable land, has been affected by earthquakes, for example, the Koyna earthquake.

During the investigation on Yamuna hydroelectric project in the Himalayan terrain of Uttar Pradesh, J.B. Auden (1942) observed that the effect of earthquakes is generally restricted within the top 30 m of the ground.

Hence, if the tunnel grade is constructed sufficiently below this depth, the earthquake may not cause serious damage to the tunnel. A tunnel may pass a thrust or major fault in the extra-peninsular region; the release of accumulated stress brings about movement along these planes.

The intensity of probable earthquake in an area is known from seismic zoning map and accordingly suitable design is prepared for tunneling through the terrain.