3.2 Geological Survey for Tunnels:

Objects:

Geological investigations are very essential in tunneling projects.

(a) Selection of Tunnel Route (Alignment)

There might be available many alternate alignments that could **connect two points** through a tunnel.

However, the **final choice** would be greatly **dependent** on the **geological condition** along and around different alternatives: the alignment having least geologically negative factors would be the obvious choice.

(b) Selection of Excavation Method:

Tunneling is a **complicated** process in any situation and involves **huge costs** which would multiply manifolds **if proper planning is not** exercised **before** starting the actual **excavation**.

And the **excavation methods** are intimately **linked** with the **type of rocks** to be excavated. **Choice** of the **right method** will, therefore, be possible only when the **nature** of the rocks and the ground all **along the alignment** is fully **known**. This is one of the most **important aim** and object of geological investigations.

(c) Selection of Design for the Tunnel:

The ultimate **dimensions** and design parameters of a proposed tunnel are controlled, besides other factors, by **geological** constitution of the area along the alignment.

Whether the tunnel is to be **circular, D-Shaped, horse-shoe shaped or rectangular** or combination of one or more of these outlines, is more often dictated by the geology of the alignment than by any other single factor.

Thus, in self-supporting and strong rocks, either, **D-shape or horse-shoe** shape may be conveniently adopted but these shapes would be practically **unsuitable** in **soft ground** or even in weak rocks with **unequal lateral pressure**. In those cases **circular** outline may be the **first choice**.

(d) Assessment of Cost and Stability:

These aspects of the tunneling projects are also closely **interlinked** with the **first three considerations**. Since geological investigations will determine the line of actual excavation, the method of excavation and the dimensions of excavation as also the supporting system (lining) of the excavation, all estimates about the cost of the project would depend on the geological details.

Similarly tunnels passing through hard and massive rocks even when left unsupported may be regarded as stable. However, those passing through difficult grounds, although these might have been massively strengthened by secondary support system, might still collapse or bulge at places or even completely fail, if geological situation is not perceived properly.

(e) Assessment of Environmental Hazards:

The process of tunneling, whether through rocks or through soft ground, and for whatsoever purpose, involves disturbing the environment of an area in more than one way. The tunneling methods might involve vibrations induced through blasting or ground cutting and drilling, producing abnormal quantities of dust and last but not the least, interference with water supply system of the nearby areas.

A correct appreciation of geological set up of the area, especially where tunnel alignment happens to be close to the populated zones, would enable the engineer for planning and implementing plans aimed at minimizing the environmental hazards in a successful manner.

<u>The stages in geological survey</u>

A. Preliminary Surveys:

These are conducted by the **routine** geological, geophysical and geochemical methods. In modern practice and for major tunneling projects such fast techniques as aerial photography and seismic surveying are commonly adopted in combination with the routine surface methods.

Following geological characters are broadly established for the entire area in which the tunnel project is to be located as a result of preliminary surveys:

(a) The general topography of the area marking the highest and the lowest points, occurrence of valleys, depressions, bare and covered slopes, slide areas, and in hilly regions and cold climates, the snow-line.

(b) The lithology of the area, meaning thereby, the composition, attitude and thickness of rock formations which constitute the area.

(c) The hydrological conditions in the area, such as depth of water table, possibility of occurrence of major and minor aquifers of simple type and of artesian type and the likely hydrostatic heads along different possible routes or alignments.

(d) The structural condition of the rock, that is, extent and attitude of major structural features such as folding, faulting, unconformities, jointing and shearing planes, if developed. Existence of buried valleys is also established during the preliminary surveys.

B. Detailed Surveys:

Once the general run of the tunnel has been decided, planning for its construction begins. Such plans require fairly accurate data about the rocks or the ground to be excavated for passing through.

Such data are obtained by:

(i) Bore-hole drilling, along proposed alignments and up to desired depths; the number of bore-holes may run into dozens, scores or even hundreds, depending upon the length of the tunnel; rock samples obtained from bore holes are analysed for their mechanical and geochemical properties in the laboratories;

(ii) Drilling exploratory shafts and adits, which allow direct approach to the desired tunnel for visual inspection in addition to the usual advantages of drilling;

(iii) Driving pilot tunnels, which are essentially exploratory in nature but could better be used as a main route if found suitable by subsequent enlargement.

(iv) The actual number of bore holes and shafts and adits and their depth and length are decided by the length and location of the proposed tunnel. For tunnels with little overburden, these may be driven close to the proposed tunnel. For very long and deep tunnels, economic considerations limit their number.

Sample of rocks obtained by direct methods from underground locations are tested in the laboratories for their:

(i) Mineralogical composition;

(ii) Strength values;

(iii) Modulus of elasticity;

(iv) Porosity and permeability and

(v) General chemical character.

In rock, continuous rock core should be obtained below the surface of rock, with a minimum NX-size core (diameter of 2.16 inch or 54.7 mm).

Double and triple tube core barrels should be used to obtain higher quality core more representative of the in situ rock.

For deeper holes, coring should be performed with the use of wire-line drilling equipment to further reduce potential degradation of the recovered core samples. Core runs should be limited to a maximum length of 10 ft in moderate to good quality rock, and 5 ft in poor quality rock.

The rock should be logged soon after it was extracted from the core barrel. Definitions and terminologies used in logging rock cores are presented in Appendix B. Primarily, the following information is recommended to be noted for each core run on the rock coring logs:

- Depth of core run
- Core recovery in inches and percent
- Rock Quality Designation (RQD) percent
- Rock type, including color texture, degree of weathering and hardness
- Character of discontinuities, joint spacing, orientation, roughness and alteration