Unit 6: Tunnel Engineering

TERMINOLOGY

Open cut: It is open to sky passage excavated through huge soil mass of obstacle, like hill, run in required direction to connect two roads or railways.

Bridge: It is an over ground construction to cross over obstacles safely without much disturbing the natural way below it.

Tunnel Approach: These are open cuts on both sides of the tunnel. In case of very steep hill slopes, these are very short while for flat sloped hills these are longer.

Shafts: The vertical wells or passages constructed along the alignment of a tunnel are known as shafts.

ADVANTAGES OF TUNNELS

1. Generally when depth of open cut is more than 18 m, tunneling is economical.
2. Tunnels avoid disturbing or interfering with surface life and traffic during construction.
3. For carrying public utilities like water, or gas, railway lines or roads across a stream or a mountain, tunnels may be cheaper than bridges or open-cut.
4. Tunnels avoid the dangerous open cut adjacent to the structure.
5. Tunnels avoid traffic congestion and provide rapid transportation in crowded cities.
6. Tunnels connect two terminal stations by shortest route.
7. Tunnels permits easy gradients in mountainous terrain and thereby encourage high speed of vehicles.
8. If tunnels are provided with easy gradients, the cost of hauling is decreased.

9. During war time tunnels protect the system from destruction due to bombarding.

10. Modern methods of construction have eliminated the danger of settlement of overlaying ground providing safety in tunnel construction.

SHAPE OF TUNNELS

Various cross-sections may be adopted for tunnels, the deciding factors being nature of soil through which tunnel is to be driven and certain practical considerations.

The following shapes or cross-sections of tunnels commonly adopted:

1. Circular section
2. Elliptical section
3. Egg-shaped section
4. Segmental roof section
5. Horse shoe section
6. Rectangular section

CIRCULAR SECTION

This type of section offers greater resistance to external pressure. If the ground is highly unstable, such as soft clay or sand, it is necessary to use circular section. For carrying water and sewerage under pressure these tunnels are the best for resisting external and internal pressures caused by water bearing soil or soft grounds.

ELLIPTICAL SECTION

They are used in grounds softer than rock. To have better resistance to external. Pressure, the major axis of these tunnels is kept vertical. These tunnels serve as water and wage conduits. They are difficult to construct. They cannot be used as traffic tunnels cause of their narrow base.

EGG SHAPE SECTION

These sections have narrower cross- sections at bottom. They are best suited for carrying sewage.

Advantages:

1. They maintain self-cleansing velocity of flow of sewage both in dry and rainy seasons.
2. They also resist external as well as internal pressure due to their circular walls.

Disadvantages:

1. Providing Concrete lining is difficult task.
2. These tunnels are difficult to construct.
3. It used for carrying Sewage.

SEGMENTAL-ROOF OR D-SHAPE SECTION

This section is suitable for sub-ways or navigation tunnels. The section has its roof as segmental in shape with vertical sides and flat floors. The segmental roof takes the external load and transfers it on the vertical side-walls. This section is suitable for hard rocks. In case of soft soils the side-walls are to be constructed in R.C.C. for taking external forces. They are easy to construct. However, these tunnels require comparatively thick lining.

HORSE SHOE SECTION

This form consists of a semi-circular roof together with arched sides and a curved invert. They are suitable in soft rock grounds. It offers a good resistance to external ground pressure. They are most popular as traffic tunnels for roads and railway routes. They have enough flat bases to provide working space during its construction.

ADVANTAGES OF HORSE-SHOE SECTION:

1. Curved sides and inverts resist the external pressure by arch action.

2. This section is most suitable for soft rocks.

3. This section provides sufficient working space for the workers and strong materials during construction.

4. This section is also suitable for carrying water or sewage, as the wetted perimeter in this section is also not much greater than circular section.

5. This shape is very commonly used for Railway and Highway Tunnels in all countries.

TRANSFERRING ALIGNMENT INSIDE THE TUNNEL

Central line transference to the Inside of the Tunnel

This operation is very important as the alignment entirely depends upon this operation. It must be done carefully. This work needs utmost care and accuracy in execution. If it is not done carefully, center line worked from opposite faces will not meet. Thus deviation in center line will cause over breaking resulting in additional expenditure especially when the tunneling is done in hard rock.

TRANSFERRING ALIGNMENT INSIDE THE TUNNEL

Procedure:

1. Two plumb-bobs attached to fine wires are suspended in the shaft.

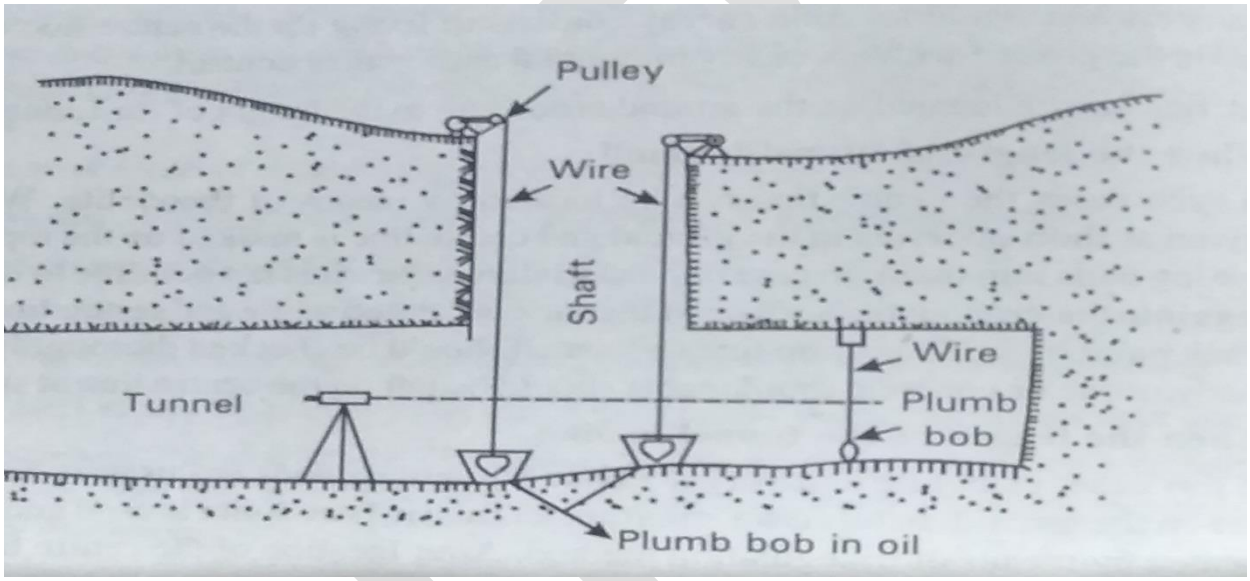
2. In the tunnel these plumb-bobs are immersed in water or oil buckets, so that they may not be affected by vibrations.

3. With the help of a theodolite these wires are brought on Centre-line at the ground.

4. When the wires at top are lying on Centre line, they will automatically be on Centre line in the shaft also.

5. Now one theodolite is kept about 7 meters away from wires in such a way that, when observing through the telescope both wires are in one line. In this position the axis of telescope will i.e. in the Centerline of the tunnel.

6. The construction of the tunnel in one or both the directions started along the Centerline, which has been fixed by driving the pegs in the roof of the tunnel, rid suspending plumb-bobs.



SHAFT

Shafts are vertical tunnels or wells or passages, reaching from the ground surface down to the tunnel invert. They afford manifold advantages and are used in constructing tunnels. When the position and course of the tunnel are correctly aligned and accordingly set out on the surface, shafts are sunk at suitable points on this tunnel line to aid tunneling operations.

Classification of shafts

Depending upon the position, the shafts are classified as follows:

1. Vertical shafts
2. Inclined shafts
3. Permanent shafts
4. Temporary shafts

MUCKING

Mucking is removal of the blasted debris or spoil from the tunnel interior to sites outside the tunnel entrance. In all big tunnel conductions, this is to be reckoned as a major item of expenditure and efficient and quick removal of muck minimizes working costs.

TUNNEL LINING

Lining is the operation of providing impervious layer to give shape to the tunnel cross-section and to give strength to the side and roof to prevent them from collapsing.
If the tunnel is subjected to internal or external or heavy ground pressure, the provision of lining will result in the increase of strength of the tunnel C/S.

VENTILATION OF THE TUNNELS

Ventilation of the tunnel is the provision of sufficient quantity of fresh air in the Tunnel so that workmen in the tunnel may not feel
discomfort. Ventilation helps to bring down the rise in temperature inside the tunnel.

METHODS OF VENTILATION

Any one of the following methods may be employed for providing ventilation in the tunnels:

l. Natural methods

2. Mechanical methods

Natural methods

Fresh ventilation to the workers in the tunnel is provided from the drift driven between the portals (From one portal to the other). On account of difference of temperature between inside and outside of the tunnel natural ventilation is provided. It will be effective if the orientation of the tunnel is along the direction of the wind. Natural ventilation can be improved by providing shafts at a suitable interval along the alignment of a tunnel during its construction.

Mechanical methods

a. Blowing: In this method, fresh air is blown by blower fans. The fans are mounted in one or more input shafts. The foul air is forced out through the portals.

b. Exhausting: This is also referred as 'Vacuum Process' and in this method, foul air and dust are taken out into an exhausting duct near the working face thus creating a flow of fresh air into the tunnel from the portal or inlet-shafts.

c. Combination of blowing and exhausting: In this method, blower and exhaust fans are provided for providing fresh air in the tunnel and sucking foul air from the tunnel respectively.

DRAINAGE OF TUNNELS

The art of collection and removal of water entering the tunnels during and after their construction is known as drainage of tunnels. Generally at the time of construction the water which is used for wet drilling and which comes through seepage is removed by pumps. After the completion of the tunnel the water is taken out by means of open drains provided in the Centre or both sides of the tunnel by gravitational force.
Sufficient slope is provided in the drains to take out water from the tunnel.

Types of Drainage

1. Temporary drainage system

   The drainage system provided during the construction of a tunnel is known as temporary drainage system.

2. Permanent drainage system

   The drainage system provided after the construction of tunnel is known as permanent drainage system.