TUNNEL ENGINEERING

INTRODUCTION

- Tunnels are underground passages used for transportation. They could be used for carrying freights and passengers, water, sewage, etc.
- The methods involved are underground operations known as tunnel driving and the surface is not disturbed
- It is understood that first tunnel was constructed by *Egyptians* and *Babylonians* about 4000 years ago. It was built to connect two buildings in Babylon. The length, width, and height of this tunnel were 910 m, 360 cm, 450 cm respectively.

ADVANTAGES OF TUNNELING

- Tunnels are more economical than open cuts beyond certain depths
- Tunnels avoid disturbing or interfering with surface life and traffic during construction
- Tunnels prove to be cheaper than bridges or open cuts to carry public utility services like water, sewer and gas
- if tunnels are provided with easy gradients, the cost of hauling is decreased
- In case of aerial warfare and bombing of cities, the tunnels would grant better protection as compared to bridges

ECONOMIES OF TUNNELING

- In general it depends on relative cost of open tunnel *vs* tunelling some aspects are given below.
- Nature of soil, particularly in deep cutting, with the consequent side slopes and volume of excavation
- If the soil is hard rock, the open cut could be of steep slope, involving much less volume of excavation and may prove cheaper
- The requirements of fill in the neighborhood also largely influence the choice. If a large amount of material is needed for the nearby fill, an open cut may be justified

Shape of tunnels

SELECTION OF ROUTE OF TUNNEL

- *Alignment restraints:* Underground space is a heterogeneous mass and in addition, problems like water table, position of fractured rocks etc. are to be tackled. A through detailed inspection and evaluation of the existing alignment restraints of underground space should therefore be made & correlated with the tunneling technology to be adopted for the project
- *Environmental considerations:* The site of tunnel should be selected in such a way that the least difficulty is experienced for various environmental factors such as disposal of exhaust gas, groundwater, muck, etc.

TUNNELLING THROUGH ROCK

- *Full face method*: The full face method is adopted only for small tunnels whose dimensions do not exceed about 3 m. The vertical columns are fixed at suitable height. A series of drillholes about 10 mm to 40 mm diameter are drilled at about 1200 mm centres.
- *Heading & bench system*: This is the method usually adopted for all railway tunnels. The heading is the top portion which will be 3700 mm to 4600 mm ahead of the bottom portion known as *bench*.
- *Cantilever car dump method*: This arrangement consists of two plate girders about 23 m long and fixed at 1800 mm centres. A belt conveyor fitted with a number of jacks is running on these plate girders, the ends of which project beyond full face of the bench.

TUNNELLING THROUGH ROCKS (CONTD)

- *Drift system*: In this system, a drift is first driven of appropriate size, usually of 3000 mm by 3000 mm. The drillholes are provided all round the drift in entire cross section of tunnel.
- *Pilot tunnel method*: The *pilot tunnel* which is first driven to full size is connected to the centre-line of the main tunnel, can be started from a number of holes. The pilot tunnel also helps in removal of muck and the lighting and ventilation of the main tunnel

TUNNELLING THROUGH SOFT GROUND

- *Forepoling method*: In this method, a frame in the shape A is prepared and placed near the face of the tunnel covered with suitable planks. The poles are then inserted at top and continued to a depth upto which they can be easily taken up. The forepoling is an old method and it can be used successfully used for carrying out tunnelling operations through soft ground.

- *Needle beam method* : This method is useful when the soil is hard enough to stand for few minutes. A small drift is prepared for inserting a needle beam consisting of two I-girders and bolted together with a wooden block in the centre.

TUNNELLING THROUGH SOFT GROUND
(CONTD)

- *Five-piece set method*: In this method, the widening of the tunnel is carried out by using a set of timbering consisting of five pieces.
- *Linear plates method*: In this method, the timbering is replaced by pressed steel plates of standard sizes. The advantages of this method are: They are light, Easy to handle, Larger than timber pieces, require less number of joints, They are fire-proof, They can be erected by unskilled labour .

METHODS OF TUNNELLING THROUGH SUB-AQUEOUS STRATA

- *Shield tunnelling*: A *shield* is a movable frame and it is used to support the face of the tunnel. The excavation & lining of tunnel can be carried out under protection of shield
- *Plenum process or compressed air tunnelling*: In this process, the use is made of compressed air to prevent the collapse of sides and the top of the tunnel. Theoretically 0.003 N/mm² air pressure is equivalent to 305 mm of head of water. But practically 0.0035 N/mm² pressure will be required.

DRAINAGE OF TUNNELS

- *Sumps & pumps*: The sumps connected by a pipe line are provided at a distance of about 300 m & water is pumped from one sump to another until it is thrown out of tunnel opening
- *Grouting*: The above method cannot be used, if water is percolating from the top of the tunnel. In such cases, the grouting is adopted to make the seams water-tight.
- *Pilot tunnel*: In cases where pilot tunnel at a lower level than the main tunnel is constructed parallel to it for drainage of water

LIGHTING OF TUNNELS

- The situations which demand adequate light can be obstructions in tunnel, drilling & mucking zones, bottoms of shaft, storage points, pumping stations, underground repair shops
- The spacing of lights will depend on various factors such as tunnel dimensions, size of light source, nature of rock surface.
- The common types of lights used in tunnelling work are acetylene gas lighting, electric lighting & lanterns

USE OF ELECTRIC LIGHTING

SHAFTS & MUCKING

- *Shafts*: The *shafts* are used for ventilation after the construction of tunnel. They are also useful to accommodate the pipes of fans during construction work
- *Mucking*: In case of tunnelling through rocks, the blasted rock or earth has to be removed from the tunnel. This process is known as *mucking*

A SHAFT IN TUNNEL

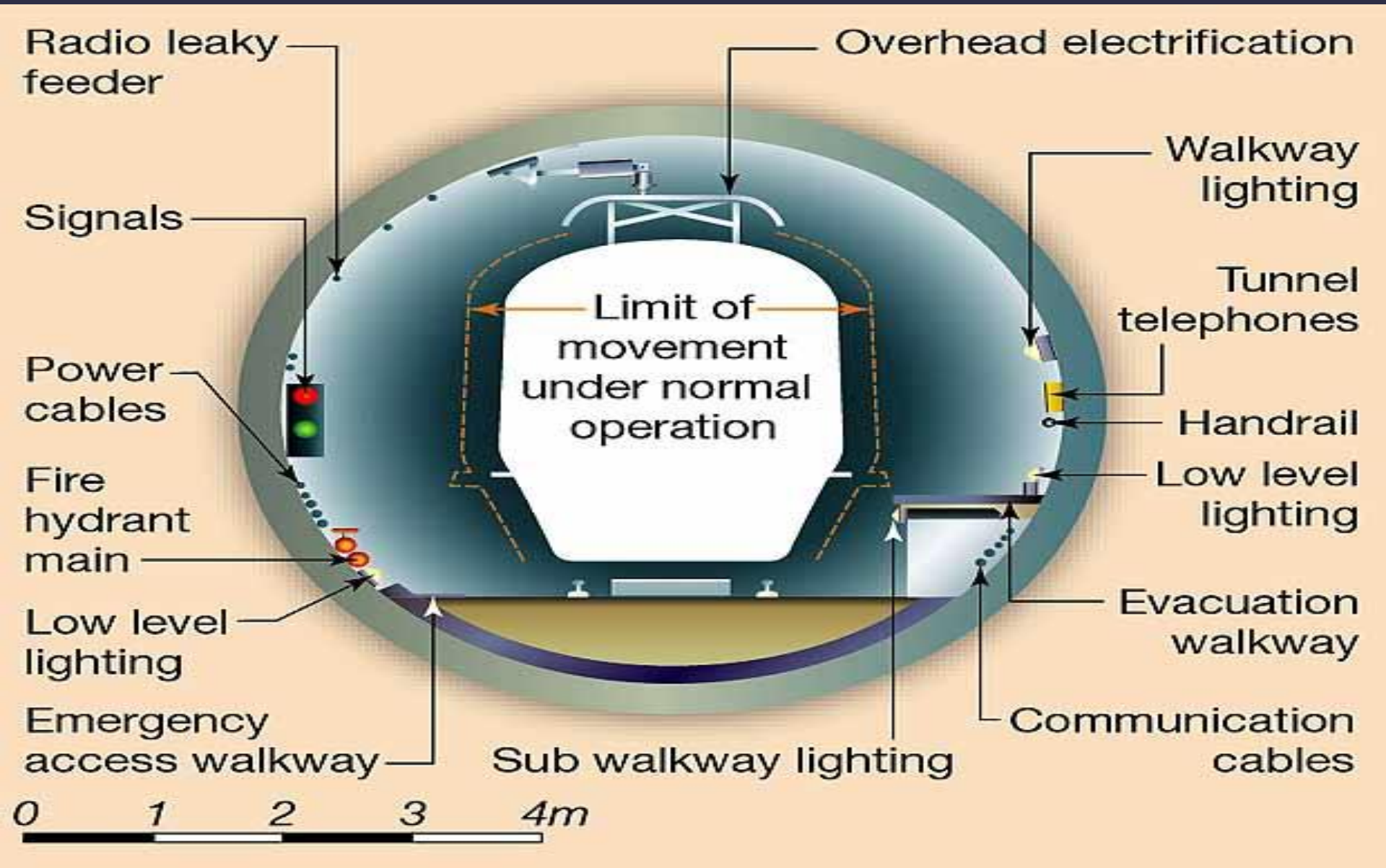
VENTILATION OF TUNNELS

- *Blow-in method*: In this method fresh air is forced by a fan through a pipe & is supplied near face. This method has the *advantage* that a positive supply of fresh air is guaranteed where it is required.

- *Exhaust method*: In this method the foul air is pulled out through a pipe & is exhausted by a fan. This sets up a current of fresh air to enter the tunnel. This method has the *advantage* that the foul air is kept out from working place.

INSIDE OF A TUNNEL

A TRANSIT RAILWAY TUNNEL



LINING OF TUNNELS

- The lining will be required practically in all the types of tunnels to give a finishing touch to the tunnel cross-section. Most common materials used as lining are stones, bricks, cement concrete, rubber & pre-cast pipes.
- In rocky ground, the lining can be carried out in any one of following ways:
- Invert first and then sides & top
- Side walls first and then arch section and then invert
- Full section in one operation

SHAPE & SIZE OF TUNNELS

- The size of the tunnel is determined by its utility. For irrigation purpose, the tunnel is generally designed to run full & if lining is of concrete, the velocity is taken as 366 cm/sec. In case of road tunnels, it will depend no. of traffic lanes & in case of railway tunnels, it will depend on the no. of lines & type of gauge.

- The shape of tunnel is determined by the material of which the cross-section is built & material through which the tunnel is bored.

MAINTENANCE OF RAILWAY TUNNELS

- The slopes of portals at entry & exit should be checked.
- It should be seen whether the masonry has crushed, cracked or deteriorated.
- The track through the tunnel should be in line and level.
- The dimensions of tunnel should conform to original dimensions.
- The lining of tunnel should be examined & checked if it is in a satisfactory condition.