SOLUTIONS

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SUBJECT: TRANSPORTATION ENGINEERING-II
SECTION-A

1. Choose the correct answer:

i. (a) 1.676
ii. (a) Traffic
iii. (c) Creep
iv. (b) Angular
v. (d) All of the above
vi. (a) Centripetal, Centrifugal
vii. (a) Tongue
viii. (b) Co-acting
ix. (a) Horse shoe
x. (c) Dead weight tonnage

SECTION-B
UNIT-1

Solution 2(a) :

After reconnaissance survey, preliminary survey is conducted. This survey is done with great accuracy along all the alternatives and total cost of different routes is calculated.

Various instrument used in preliminary survey are Theodolite, Tacheometer, Dumy level, Plane table and Prismatic compass.

An open traverse survey in a belt of 200 to 300 m width on either side of the centre line of the proposed alternatives are carried out in the preliminary survey. Final drawing and details for each alignment are prepared by giving the following information :

(i) Quantity of earthwork.
(ii) Length of alternate routes.
(iii) Maximum length and height of cutting and embankment.
(iv) Bearing capacity of soil,
(v) Water table position.
(vi) Details of existing bridges, tunnels or culverts.

At the end, comparative study of all the alternative routes is made with its merits and demerits. The route which is most economical and best suited is selected and plotted on the map.

Solution 2(b) :

Before starting any big railway project the future earning should be considered. The earning directly depends upon the traffic at present and traffic in immediate future, both passengers and goods traffic. To know the potential of available traffic in the route, traffic survey is conducted. In the traffic survey the following information should be collected :

(i) Population of the cities, towns and villages lying within 15 kms on both sides of the track.

(ii) Approximate number of passengers who will use trains.

(iii) Position of local industries.

(iv) Future prospects of development of industries and trade centres.

(v) Nature and volume of exports and imports with centres of their destination.

(vi) Fairs, recreation centres, religious festivals in different places which can attract the traffic.

(vii) Location of railway stations to get more business.

(viii) General character of land and communities.

After collecting the above information, the cost of railway per kilometre is calculated from the previous experience. Then the approximate expenditure, the operating cost and revenue earned is calculated.

In this type of survey the following maps are prepared for the study :

(i) Topographical maps

(ii) Agricultural maps

(iii) Industrial maps

Reconnaissance survey is a rough inspection of various physical characteristics of the area to investigate the suitability of different alignments marked on the available map. With this type of survey, approximate alignment is fixed. Prismatic compass, Abney level, Telescope and Pedometer are used in the reconnaissance survey. The objectives of reconnaissance survey are :

(i) To acquire the knowledge of physical features like forests, hills, rivers etc.

(ii) To collect the geological information regarding nature of soil, hill slopes etc.

(iii) To get an idea about possible alignments

(iv) To decide maximum gradient and curvature for proposed alignment.

(v) To get information regarding availability of materials, labour and water.

(vi) To prepare rough estimates for the approximate alignments.

A map showing all the physical features and two or three suitable alignments is prepared at the end of this survey.

Solution 3:

Gauge is the clear horizontal distance between inner or running faces of two rails forming a track

Types of Gauges

Following three types of gauges are prevalent in India :

(i) Broad gauge (B.G.)

(ii) Metre gauge (M.G.)

(iii) Narrow gauge (N.G.)

(i) **Broad Gauge :** When the clear distance between the inner faces of two rails is 1.676 m, the gauge is called *Broad gauge*. This is also called *Standard gauge*.

(ii) **Metre Gauge :** When the clear distance between the inner faces of two rails is 1.0 m, the gauge is called *Metre gauge*.

(iii) **Narrow Gauge :** When the clear distance between the inner faces of two rail is 0.762 m, the gauge is called *Narrow gauge*.

When the gauge is 0.610 m then it is called *Feeder track-gauge* or *Light gauge* (L.G.).

The following factors govern the adoption of a particular gauge :

(i) **Availability of Funds :** The selection of a particular gauge depends upon the available fund for the railway project. The construction of a Broad gauge require more fund than the Metre or Narrow gauge due to following reasons:

(a) Wider gauge requires more land width and hence land acquisition cost is more.

(b) Volume of earthwork is more for wider gauge and hence cost of earth work is more.

(ii) **Volume and Nature of Traffic :** For heavier loads and high speed traffic wider gauges are preferred. Wider gauges have more load carrying capacity and hence the operating cost of trains per tonne per km run is less.

(iii) **Future Development of the Area :** Wider gauges are generally preferred in area which have the prospect of future development. Due to development of a particular area the intensity and nature of traffic changes. Once a track is laid on an area it is not economically feasible to change the width of the gauge frequently and hence wider gauges are provided in areas of future development. Narrow gauge is used to develop thinly populated area by joining poorly developed areas with developed or urban areas.

(iv) **Physical Features of the Country :** In hilly regions where broad and metre gauge tracks are difficult to lay due to steep gradients and sharp curves, narrow gauges are provided.

(v) **Speed of Traffic :** The speed of a train is almost proportional to the gauge. Speed is the function of diameter of wheel and the diameter of wheel is limited by the gauge. Generally the wheel diameter is 0.75 times that of a gauge. Hence for higher speed of traffic broad gauges are preferred.

Solution4(a):

A Ideal rail joint should fulfil the following requirements :

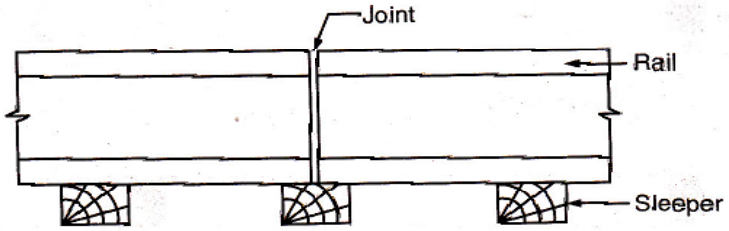
(i) It should be as strong and stiff as the other portion of the track.
(ii) It should be elastic both laterally and vertically.
(iii) It should have enough expansion gap for free expansion of rails due to temperature variation.
(iv) It should not allow the rail ends to get battered in any case.
(v) The two adjoining rail ends at the joint should remain true in line both laterally and vertically when the train passes over it.
(vi) A good joint should faciliate easy removal and replacement of rails without disturbing the whole track.
(vii) It should have minimum initial as well as maintenance cost.

Solution4(b):

The following types of rail joints are commonly used on Indian Railways.

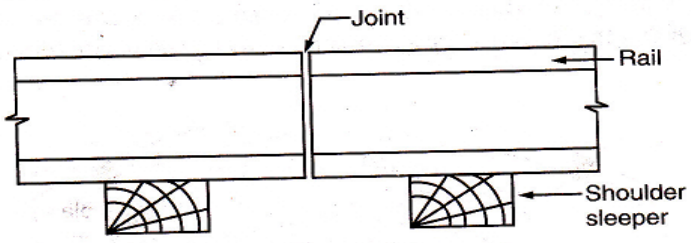
(a) Supported rail joints
(b) Suspended rail joints
(c) Bridge rail joints
(d) Welded rail joints
(e) Square or even rail joints
(f) Staggered or broken rail joints
(g) Compromise rail joints
(h) Insulated rail joints

(a) **Supported Rail Joints :** The rail joints in which the rail ends rest on a single sleeper, called a "joint sleeper", are known as *supported rail joints*.



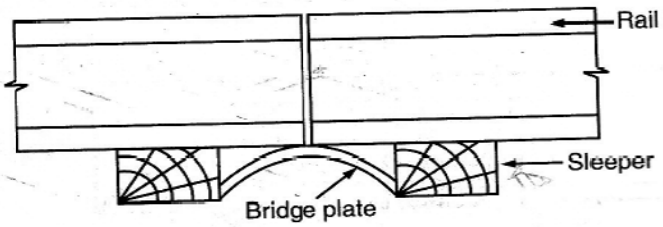
Supported rail joint

(b) **Suspended Rail Joints :** The rail joints in which the rail ends are projected beyond sleepers, called "shoulder sleepers", are known as *suspended rail joints*.



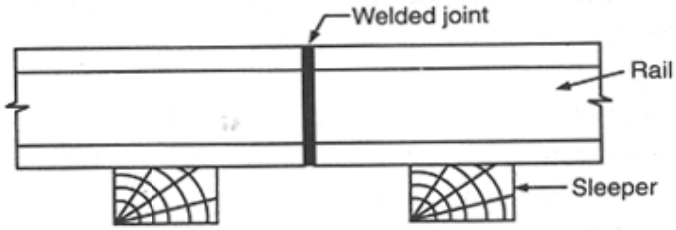
Suspended rail joint

(c) **Bridge Rail Joints :** The rail joints in which the rail ends are projected beyond sleepers and are carried by a flat or corrugated plate, called a "bridge plate", are known as *bridge rail joints*. This type of joint is not used on Indian Railway's now-a-days



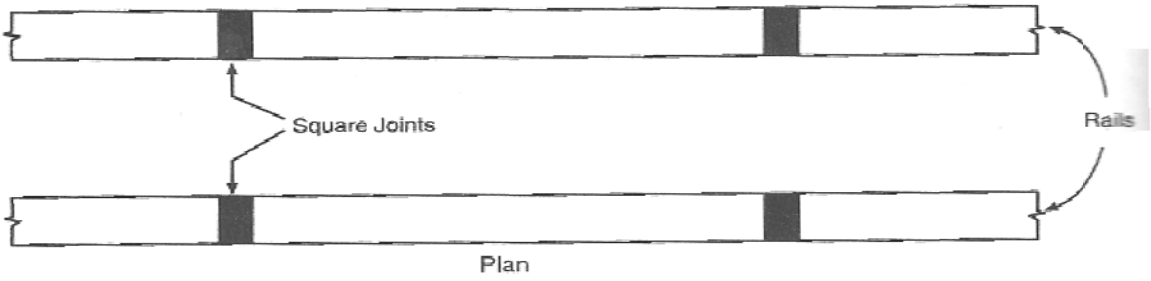
Bridge rail joint

(d) **Welded Rail Joints :** The rail joints in which the rail ends are welded together are known as *welded rail joints*. These are the best type of rail joints as they fulfil nearly all the requirement of an ideal joint. This type of joints is now-a-days more popular on Indian Railways.



Welded rail joint

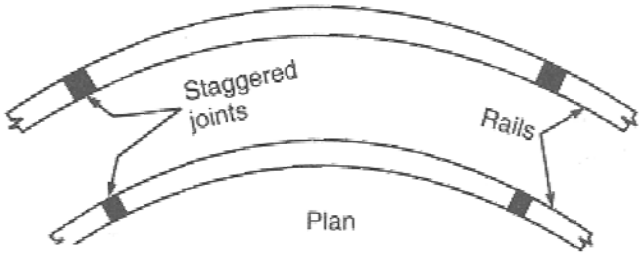
(e) **Square or Even Rail Joints :** When the joints of one rail of a track are directly opposite to the joints of other rail, these are known as square or even rail joints. These are generally used on straight length of track.



Plan

Square or even rail joints

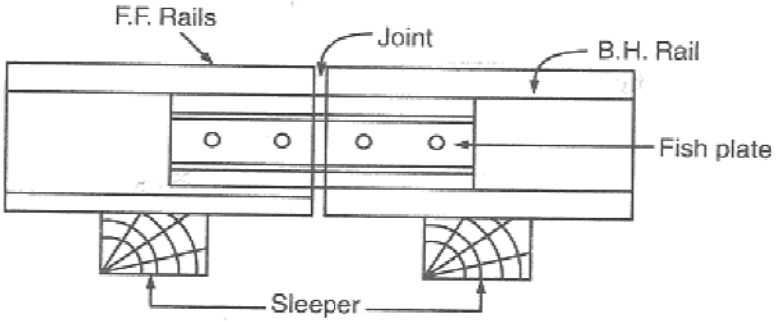
(f) **Staggered or Broken Rail Joints :** In this, the joints of one rail of a track are not directly opposite to the joint of other rail. These joints are generally provided on curved portion of the track, where the length of outer rail is greater than the length of inner rail.



Plan

Staggered or broken rail joints

(g) **Compromise Rail Joint :** The rail joints where two different railway sections are required to be joined together are known as *compromise rail joints*.



Compromise rail joint

(h) **Insulated Rail Joints :** When insulating material is inserted in a joint to stop the flow of electric current beyond the circuited part of the track, the joint is called insulated rail joints.

Solution5(a):

Railway Sleepers serve the following functions :

(i) To hold the rails to proper gauge.
(ii) To transfer the loads from rails to the ballast.
(iii) To support and fix the rails in proper position.
(iv) To keep the rails at a proper level in straight tracks and at proper elevation on curves.
(v) To provide elastic medium between the rails and the ballast.
(vi) To provide stability to the permanent way on the whole.

Solution5(b):

The following are the requirements of good sleepers :

(i) The sleepers should be sufficiently strong to act as a beam under load
(ii) The sleepers should be economical.
(iii) They should maintain correct gauge.
(iv) They should provide sufficient bearing area for the rail.
(v) The sleepers should have sufficient weight for stability.
(vi) Sleepers should facilitate easy fixing and taking out of rails without disturbing them.
(vii) They should facilitate easy removal and replacement of ballast.
(viii) They should not be pushed out easily of their position in any direction maximum forces of the moving trains.
(ix) They should be able to resist impacts and vibrations of moving trains

Solution6(a):

GRADE COMPENSATION OF CURVES

Grade compensation on curves is the reduction in gradient of curved portion of a track. On curves extra pull is required to pull the train due to more tractive resistance. Therefore, if gradients are to be provided on curves some compensation should be given in ruling gradients to overcome the increased tractive resistance to a certain limit and to pull the trains with same speed. It is expressed as percentage per degree of curve. The grade compensation provided on Indian Railway is as follows:

(i) On B.G. curves - 0.04 percent / degree
(ii) On M.G. curves - 0.03 percent / degree
(iii) On N.G. curves - 0.02 percent / degree

Solution6(b):

WIDENING OF GAUGE ON CURVES

Widening of gauge is the provision of extra guage width on the curved portion of a track. The widening of gauge on curves is essential to avoid tilting of train. When the outer wheel of front axle strikes against the outer rail, the outer wheel of the rear axle bears a gap with the outer rail due to the rigidity of wheel base. To compensate this gap gauge should be widened. The widening of gauge should be just adequate because if it is more than the required amount, the lateral play of train will be more and may result in derailment. Extra width of gauge (d) in mm is given by the formula:

$$d = \frac{130\,(B+L)^2}{R}$$

where B = Rigid wheel base in metres

For B.G. track, $B = 6$ m

For M.G. track, $B = 4.88$ m

R = Radius of the curves in meters

L = Lap of flange in metres = $0.2\sqrt{h^2 + Dh}$ meters

h = Depth of wheel flange below rail in mm

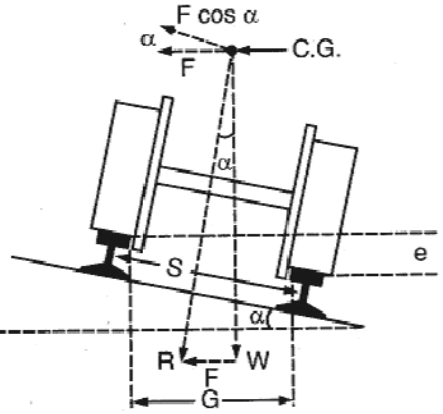
D = Diameter of wheel in mm.

Solution7:

SUPERELEVATION

Superelevation is the raised elevation of the outer rail above the inner rail at a horizontal curve. It is denoted by 'e'.

When a vehicle moves on curve it is subjected to a centrifugal force. The centrifugal force exerts a horizontal force on the outer rail and the weight of the outer rail increases. This horizontal force and uneven load on rails will cause derailment. This centrifugal force can be counteracted by introducing the centripetal force by raising the outer rail with respect to inner rail. This raising of outer rail with respect to inner rail is known as '*superelevation*' or '*canting*'



Superelevation

Objects of Providing Superelevation

The following are the objects of providing superelevation:

(i) To introduce centripetal force to counteract the centrifugal force to avoid derailment and reduce the side wear of rails.

(ii) To distribute the wheel loads equally on the two rails. This reduces the top wear of rails and results in saving of maintenance cost.

(iii) To ensure comfortable ride to passengers and safe movements of goods.

Solution8:

SIGNALLING

Signalling is the device by which movement of trains is controlled effectively to maintain safety of passengers, staff and the rolling stock.

OBJECT OF SIGNALLING

Following are the objects of signalling :

(i) To provide facilities for safe movement of trains.
(ii) To maintain a safe distance between trains moving in the same direction on one line to avoid accidents.
(iii) To protect the trains against collision and derailment at converging junctions.
(iv) To give indication in which direction trains have to move at diverging junctions.
(v) To guide the trains during repair and maintenance work of tracks.
(vi) To provide facilities for safe and efficient shunting operations in marshalling yards.

TYPES OF SIGNALS

The various types of signals have been classified into the following categories :

1. Classification based on their operation :
   (a) Detonating signals
   (b) Fixed signals
   (c) Hand signals
2. Classification based on their function :
   (a) Semaphore signals
   (b) Warner signals
   (c) Shunting signals (Disc signals)
   (d) Coloured light signals
3. Classification based on their location :
   (a) Outer signal (b) Home signal
   (c) Starter signal (d) Advance starter signal
4. Classification based on specific purposes:
   (a) Repeater or co-acting signals
   (b) Routing signals (c) Call on signals
   (d) Point indicator (e) Shunting signals
   (f) Miscellaneous signals.

Detonating Signals

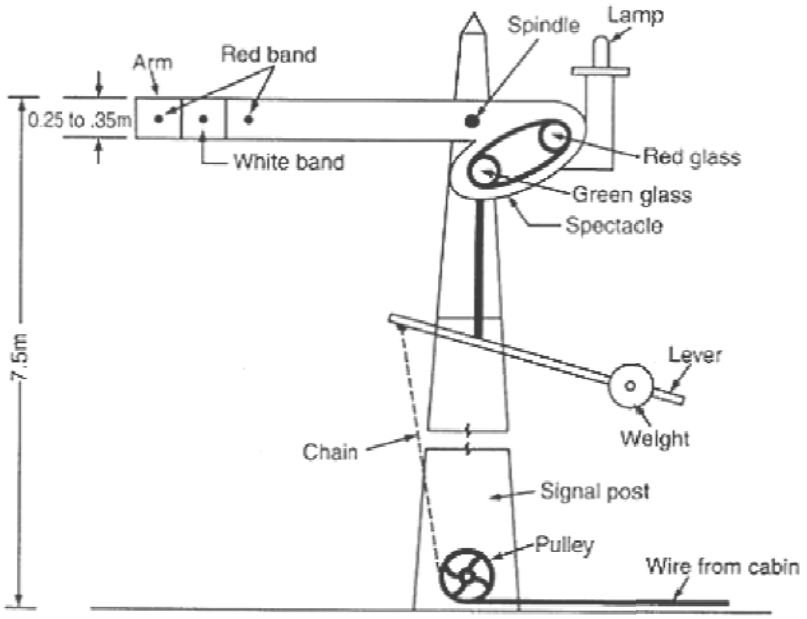
When signalling system was not properly developed, this type of signals were used during cloudy and foggy weather. Detonating signals are not in use these days. In this, detonators were placed on the rails which exploded with a loud sound when a train moved over it. Detonators were placed at least 400 to 500 m ahead to the signal to enables the driver to stop the train in time.

Semaphore Signals

The semaphore signals have following components :

(i) Movable arm
(ii) Weight and lever arrangement
(iii) Spectacle frame
(iv) Crank
(v) Crank rod
(vi) Signal post
(vii) A ladder

When the movable arm is in horizontal position it indicates 'stop' or 'danger' and inclined position of movable arm indicates 'Proceed'.



Semaphore signal

Warner Signals

Warner signal is like semaphore signal except that the movable arm is fish tailed. The white band of the arm is also V-shaped. The warner signal is placed on the same post of semaphore signal 1.8 m to 2.1 m below the semaphore signal. When warner signal remains horizontal, it indicates 'stop'. Warner signals are provided with yellow light. These signals are provided to warn the driver before entering a railway station.

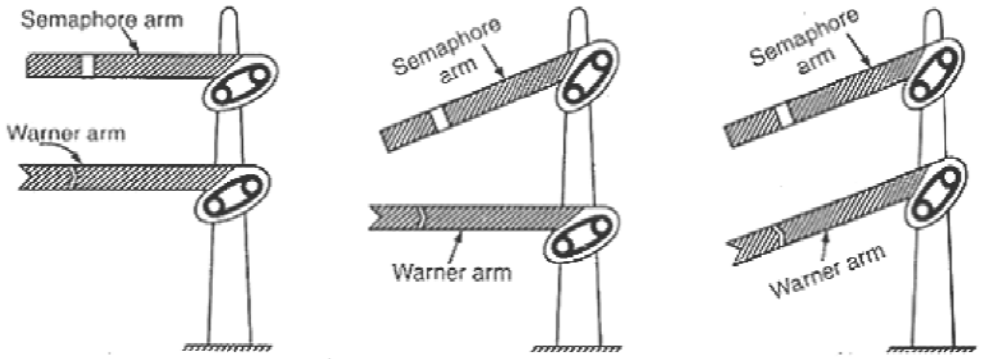
When the arm of semaphore and warner signal are horizontal, it indicates 'stop', line not clear'. When semaphore arm is lowered and warner arm is horizontal, it indicates 'Proceed with caution'. When both the arms are lowered, it indicates 'Line clear position.

Starter Signal

Starter signal gives permission to the train for leaving the platform for destination. Train standing in a station cannot move until this signal is lowered. This is placed at the end of the platform and is a stop signal when in off position.

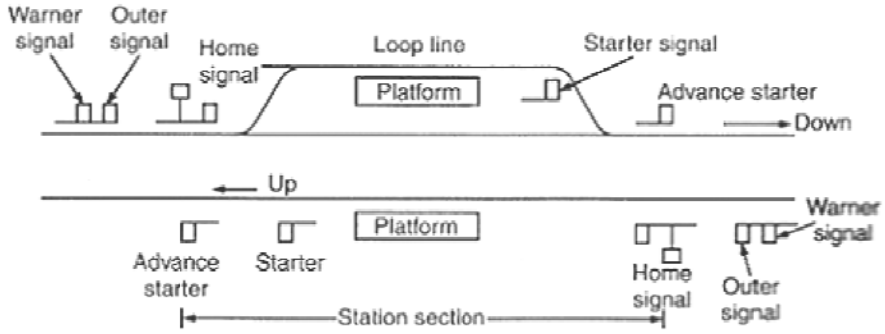
Advance Starter Signals

Advance starter signal is a stop signal, always placed beyond the outermost set of the switches. The limit of station section is indicated between advance starter signal and home signal. Advance starter signal allows train to enter in a block-section which lies between advance startor of one station to outer of another station



(a) Stop position (b) Proceed with caution (c) Line clear position

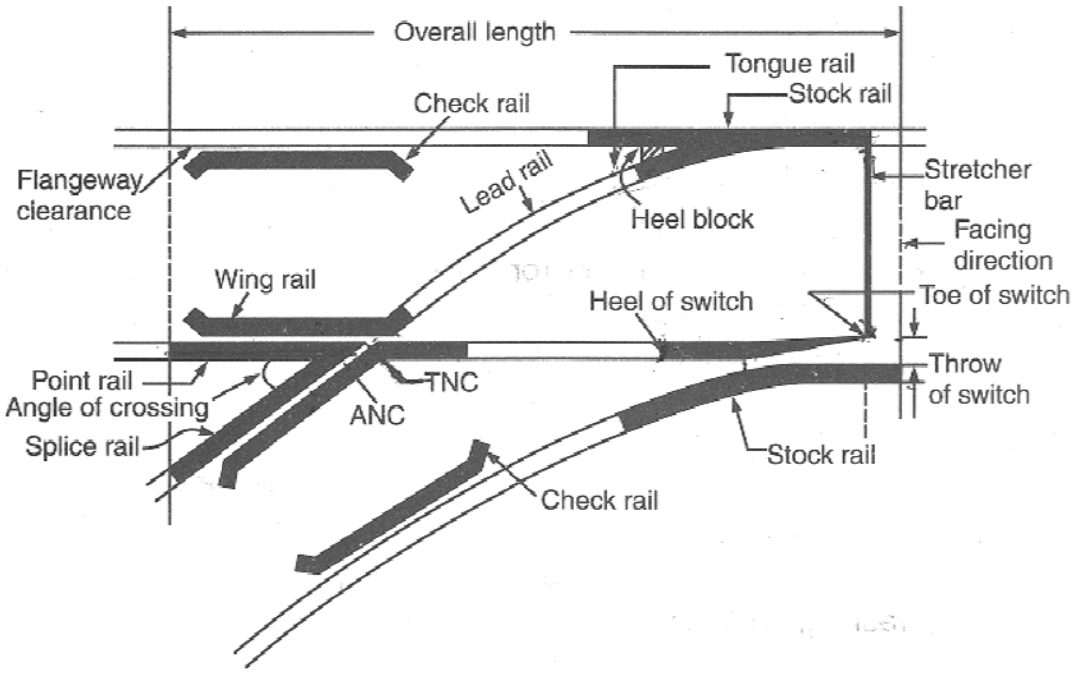
Indiations of warner signals



Position of signals in station yard

Solution9:

a. Tongue rail: The tapered movable rail, which is attached at or near one end to a running rail is called tongue rail.
b. Stock rail: Stock rail is a running rail to which a tongue rail is attached.
c. Check rail: Check rail is the rail length provided on the opposite side of crossing to check the tendency of wheel to climb over the crossing.
d. Point rail: Point rail is the rail of main track forming the nose of crossing
e. Splice rail: Splice rail is rail of branch track which meet the point rail at the nose of crossing.
f. Lead rail: Lead rail is the rail which leads the track from heel of tongue rail to the toe of crossing.
g. Heel of switch: Heel of switch is the un-tapered end of switch rails which is fixed to the lead rail.



Left hand turnout showing all the components

Solution10(a):

DREDGING DEVICES

The following equipment/Machinery are used for dredging :

(*i*) Hydraulic or suction dredge.

(*ii*) Grapple dredge.

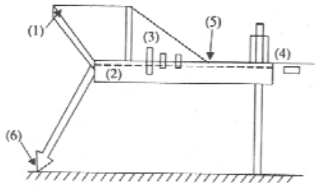
(*iii*) Continuous bucket elevator or Ladder dredge.

(*iv*) Dipper dredge.

The above devices are briefly described below :

1. Hydraulic or Suction dredge ;

The parts of the equipment are :

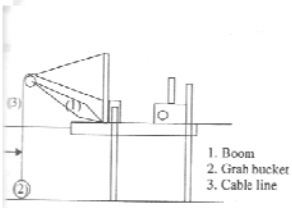


Hydraulic or Suction Dredge

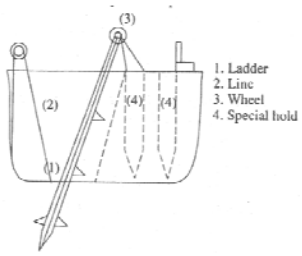
(*a*) Suction pipe which carries at its lower end a cutter with a universal joint at the top. The pipe is held in position by means of the frame. The frame itself is mounted on the bow of the dredging unit. The suction pipe leads to a centrifugal pump which has a long delivery pipe discharging on selected spot on the shore.

(*ii*) Grapple Dredge (See Fig.)

The equipment has a substantial hull rigidly connected with the frame which itself is guyed back by the back legs. The boom is fixed at the required elevation. It rotates through a horizontal angle on a pivot at the lower end. The dredge bucket is moved by the help of stakes.



Grapple Dredge.



Continuous Bucket Elevator.

When the bucket is lowered to the bottom, it bites the bed and excavated material is filled inside. The capacity of the grab bucket varies from 8 to 23 cu.m. depending upon the size of the equipment.

The dredge is very efficient and suitable for materials such as clay, sand and mud but is not suitable for removing hard core.

(*iii*) Continuous bucket elevator or dipper dredge. (See Fig.)

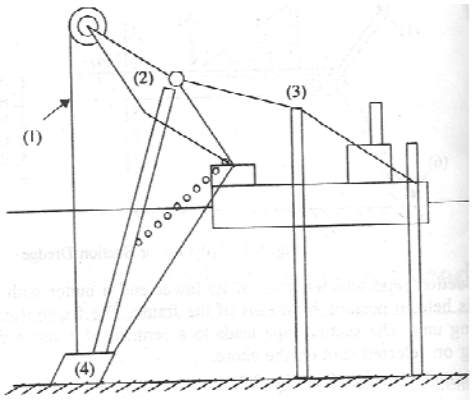
The equipment has an endless chain of buckets mounted and running around a ladder. The chain of buckets can be raised or lowered manually. The capacity of the draft is about 3 m.

The equipment is capable of digging upto 12 m per day of 8 hrs its dredging capacity is about 7500 m^3.

(*iv*) Dipper Dredge (See Fig.)

It is a floating vessel carrying an inclined frame. The dipper stick which runs through the middle of the boom is worked by rack and pinion arrangement. During dredging operation the vessel is fixed to the bed. The boom can swing horizontally.

1j. Holst cable
2. Boom
3. Incline frame
4. Dipper bucket



Dipper Dredge.

Solution10(b):

Water Transportation

Water transportation has great importance in development of trade and cultural relations. In the beginning of civilisation the modern transportation systems such as rail, road, or Air- ways were unknown and transportation by navigational channels and by sea were the only means of transportation namely by inland water transportation or by ocean water transportation

(*i*) Inland water transportation became popular in our country in 1885 after which a number of commercial towns came into existence. Most of inland transportation is by means of rivers though canal transportation has its own importance and significance.

(*ii*) Sea or ocean transportation is adopted for trade and commerce. Before the introduction of airways transportation of personnel and goods was limited to ocean which does not have any limitations. It was only this mode of transport that the continent of America was discovered in 1942.

Introduction of roadways and railways and later on of airways the water transportation got some setback. However because of the following advantages it is still an important agency for transportation as explained below :

(*i*) Unlike rail and road transport no special track is required.

(*ii*) High load carrying capacity.

(*iii*) For national security it provides a very powerful means of defence and security of the coast.

(*iv*) It still remains the most economical mode or transport for foreign trade, the other being comparatively very costly *i.e.*, transportation by airways.

(*v*) As stated in (*iv*) above oceans are the defecto international highways for trade and commerce.

(*vi*) It requires very little motive power. For example in the case of navigation by boat and ferry almost nil expenditure is required.

(*vii*) Because of contact with other countries, sea transportation has helped countries which otherwise were underdeveloped in industrialisation.

In spite of the advantages of ocean transportation, this mode of transportation has a limitations and drawbacks as stated below :

(*i*) Comparatively slow operation.

(*ii*) It is subject to sea in the form of storms and hurricanes.

(*iii*) High tides results in hindrance to operations of loading and unloading.

(*iv*) Fluctuations of water level cause rubbing of sides of ships against the berths

(*v*) It is useful when water is available in the required quantity.

(*vi*) Rapids, water falls and mountainous river hinder water transportation.

(*vii*) Sometimes waterships are used for exhibiting power.

(*viii*) In case freight traffic is at points which are not on waterways it becomes necessary to transfer from one track to another.

Solution11:

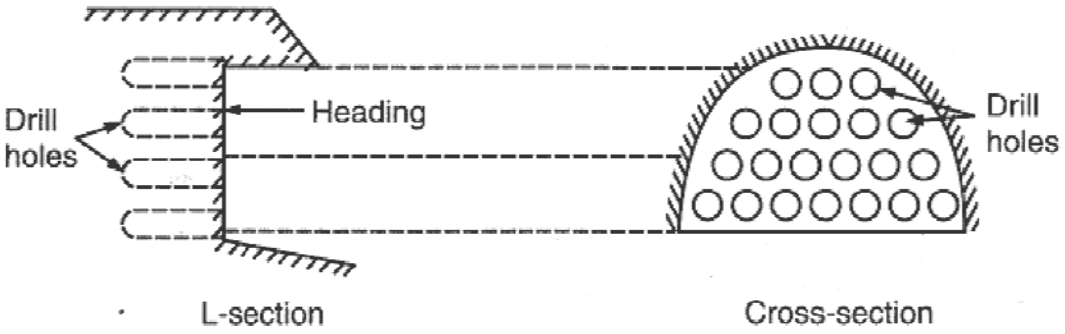
Full Face Method : As the whole section of the tunnel is attacked at the same time, so it is called full face method. This method is suitable for tunnels of small cross-sectional area.

Construction Procedure

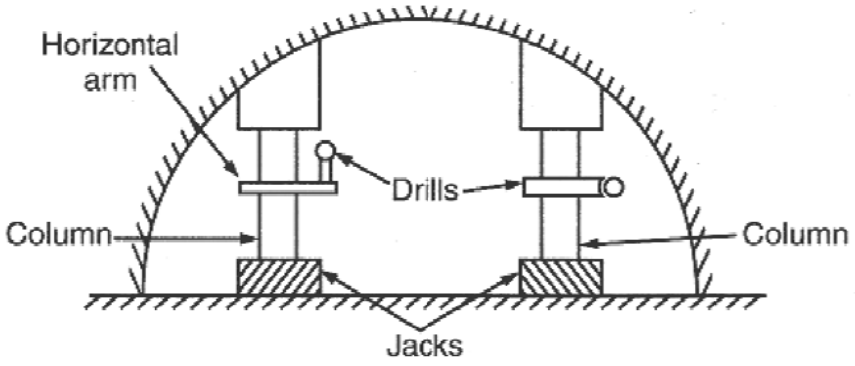
(i) Setting up and Drilling : Before starting the actual drilling, the drilling pattern and number of holes to be drilled are decided. The drilling pattern and number of holes are so selected that these break the greatest volume of rock with less quantity of explosives.

After deciding and marking the drilling pattern holes are made by using drills as shown in Fig. The holes are drilled in such a manner that these slope towards a common point or line near the centre of the face to produce an initial cone or wedge. Generally the holes are 25 to 37.5 mm in diameter and 4 m in length.

In this method of construction columns are preferred for drill mounting. Columns are extra heavy pipes fitted with one or two jacks at the bottom for weging the column tight against the roof. Drills are mounted on short horizontal arm clamped to columns. The drills can move horizontally on arms and the arms are also capable of being raised or lowered to cover desired area.



Setting up and drilling holes



Column mounting for drills

(ii) Charging and Blasting : By using high air pressure loose rock, stone dust and water are blown out after drilling. The cleaned holes are then charged and loaded with explosives. The quantity of explosives required depends upon the type of rock to be blasted. On an average the explosive required for blasting one cubm of rock is 2.0 to 2.6 kg.

(iii) Scaling : Scaling is the process of removing loose rock fragments which remain sticked with ceiling or walls of the tunnel and may fall off without warning

casusing accident. Any projection of rock is hammered off. Scaling is done by using water jets and steel rods.

(vi) Mucking : Mucking is the removal of excavated or blasted material from the tunnel site and dumping the same at a predetermined site. This is done after blasting and scaling. The operation of mucking is completed in the following three steps (*i*) loading the muck, (*ii*) hauling. (*iii*) unloading and dumping. Manual labour belt conveyors, mechanical shovels are used for mucking.

(v) Tunnel Supporting : After mucking, timbering is done to support the inner faces of blasted protion to avoid accident. Frames are erected at suitable spacing with columns and ribs. Ribs are usually made of mild steel in the form of H-section. The portion between two adjacent frames is filled with precast concrete blocks.

(vi) Grouting and Lining : Prior to lining, grouting of weaker section with cement slurry (1:3) is done to stabilise the weaker strata. After grouting, lining is done. Lining is not so necessary for railway tunnels through hard rock.

Advantages of Full Face Method

(i) Tunnelling is continuous.

(ii) As the entire section is attacked at the same time, the progress of work is more as compared to other methods.

(iii) In this method, mucking track could be laid progressively along with the tunnelling.

Disadvantages

(i) Heavy mechanical equipments are required for full face attack.

(ii) This method is limited for short spans.

(iii) This method is not suitable for unstable rocks.