Q.1 A train having 20 wagons weighing 18 tonnes each is to run at a speed of 50 kmph. The tractive effort of a 2-8-2 locomotive with 22.5 tonnes load on each driving axle is 15 tonnes. The weight of locomotive is 120 tonnes. Rolling resistance of wagons and locomotives are 2.5 kg/tonne and 3.5 kg/tonne respectively. The resistances which depend upon the speed are computed as 2.65 tonnes. Find out the steepest gradient for these conditions.

[10 marks : 1995]

Solution:

Number of wagons in the train = 20

Weight of each wagon = 18 tonnes

$\therefore$ Total weight of wagons = 18 × 20 = 360 tonnes

Also, weight of locomotive = 120 tonnes

$\therefore$ Weight of train = 360 + 120 = 480 tonnes

Now, number of driving axles in a 2-8-2 locomotive, $n = \frac{8}{2} = 4$

and load on each driving axle = 22.5 tonnes (given)

$\therefore$ Hauling capacity = $\mu n W$

where

μ = coefficient of friction which has a value = $\frac{1}{6}$

n = number of driving axles in locomotive

W = load on each driving axle

$\therefore$ Hauling capacity = $\frac{1}{6} \times 4 \times 22.5 = 15$ tonnes

Tractive effort of locomotive = 15 tonnes

We know that total resistance = $RT_1 + RT_2 + RT_3 + W \tan\theta$

where RT_1 = Rolling resistance independent of speed

$$RT_2 = \text{Resistance dependent on speed}$$
$$RT_3 = \text{Atmospheric resistance}$$

Now,
$$RT_1 = RT_1 \text{ for locomotive} + RT_1 \text{ for wagons}$$
$$= 3.5 \times 120 + 2.5 \times 360$$
$$= 420 + 900$$
$$= 1320 \text{ kg or } 1.32 \text{ tonnes}$$
$$RT_2 = 2.65 \text{ tonnes (given)}$$
$$RT_3 = 0.0000006\, WV^2$$

where
$$W = \text{Total weight of train} = 480 \text{ tonnes}$$
$$V = \text{Speed of train in kmph}$$

∴
$$RT_3 = 0.0000006 \times 480 \times (50)^2 = 0.72 \text{ tonnes}$$

Now, Hauling capacity = Total resistance

But Total resistance $= RT_1 + RT_2 + RT_3 + W \tan\theta$

⇒ $15 = 1.32 + 2.65 + 0.72 + 480 \tan\theta$

⇒ $\tan\theta = \dfrac{10.31}{480}$

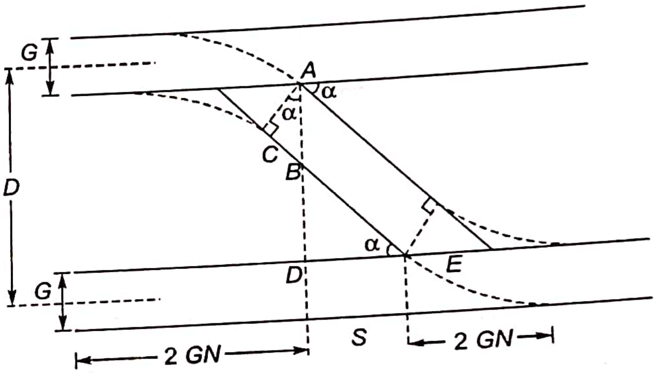
⇒ $\tan\theta = \dfrac{1}{46.56}$

Thus the steepest gradient will be 1 in 47 (approx.)

Q.2 A cross over occurs between two parallel *BG* tracks of same crossing number of 1 in 8.5 with straight intermediate portion between the reverse curve. Distance between centres of tracks is 5 m. Find the overall length of cross over.

[10 marks : 1995]

Solution:



Let
N = Number of crossing
α = Angle of crossing
G = Gauge distance (1.676 m in case of BG)
D = Centre to centre distance between two tracks
$2GN$ = Length of turnouts
S = Straight horizontal portion between the turnouts
$N = \cot\alpha$

From Δ BDE,
$$S = DE = BD \cot\alpha$$
$$= (AD - AB)\cot\alpha$$
$$= [(D-G) - G\sec\alpha]\cot\alpha \qquad \left[\because \cos\alpha = \frac{AC}{AB} \text{ and } AC = G\right]$$
$$= \left[(D-G) - G\sqrt{1+\tan^2\alpha}\right]N = \left[(D-G) - G\sqrt{1+\frac{1}{\cot^2\alpha}}\right]N$$
$$= \left[(D-G) - \frac{G}{N}\sqrt{1+N^2}\right]N$$

⇒
$$S = (D-G)\,N - G\sqrt{1+N^2}$$

But overall length of cross over $= 4\,GN + S = 4\,GN + (D-G)\,N - G\sqrt{1+N^2}$

Given that $G = 1.676$ m, $N = 8.5$, $D = 5$ m

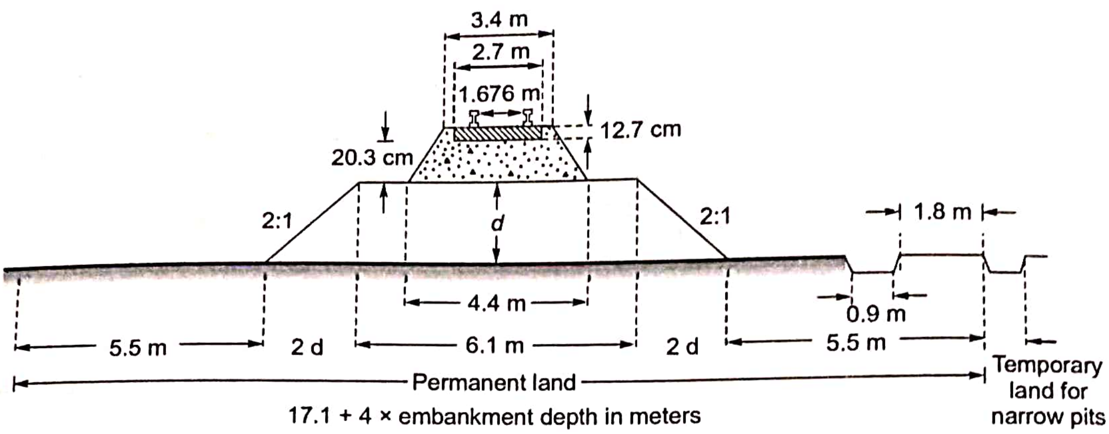
∴ Overall length of cross over $= 4 \times 1.676 \times 8.5 + (5 - 1.676) \times 8.5 - 1.676\sqrt{1+(8.5)^2} = 70.89$ m

Q.3 Draw a typical dimensional cross section of BG track in embankment on straight track and mark the details.

[6 marks : 1996]

Solution:

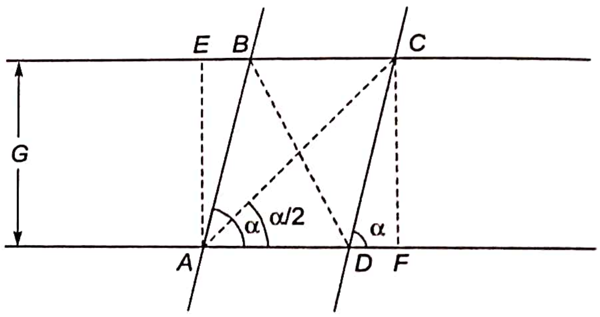
The typical dimensional cross section of *BG* track in embankment on straight track is as follows:



Q.4 Design a diamond crossing between two BG tracks crossing each at an angle of 1 in 10.

[10 marks : 1997]

Solution:



Let

$$\alpha = \text{Angle of crossing}$$
$$N = \text{Number of crossing}$$
$$G = 1.676 \text{ m}$$

From the above figure, we have

$$\sin\alpha = \frac{FC}{DC}$$

$$\Rightarrow \quad \sin\alpha = \frac{G}{DC}$$

$$\Rightarrow \quad DC = G\operatorname{cosec}\alpha$$

Also, $AB = BC = CD = DA = G\operatorname{cosec}\alpha = 1.676 \operatorname{cosec}\alpha$

Now we know that $N = \cot\alpha$

$$\alpha = \cot^{-1}(10) = 5.71°$$

(i) $AB = BC = CD = DA = 1.676 \operatorname{cosec}\alpha = 1.676 \times \operatorname{cosec} 5.71° = 16.85 \text{ m}$

(ii) $EB = DF = G\cot\alpha = GN = 1.676 \times 10 = 16.76 \text{ m}$

(iii) $BD = G\sec\dfrac{\alpha}{2} = \dfrac{G}{\cos\left(\dfrac{\alpha}{2}\right)} = \dfrac{G}{\cos\left(\dfrac{5.71}{2}\right)} = 1.678 \text{ m}$

(iv) $AC = G\operatorname{cosec}\dfrac{\alpha}{2} = \dfrac{G}{\sin\left(\dfrac{5.71}{2}\right)} = \dfrac{1.676}{0.05} = 33.65 \text{ m}$

Q.5 Sketch and briefly describe a marshalling yard.

[10 marks : 1998]

Solution:

Marshalling yard is one where trains and other loads are received, sorted out and new trains formed and despatched onwards to their destinations. The marshalling yards are provided at important junction stations which act as distributing centre for various destinations. In Marshalling yard, loaded and empty goods wagons are first received from different lines for booking in different directions and then the wagons are separated, sorted and despatched onwards in full trains for each line. While making full trains, the wagons are arranged in order of the stations to enable convenient detaching of wagons at wayside stations.

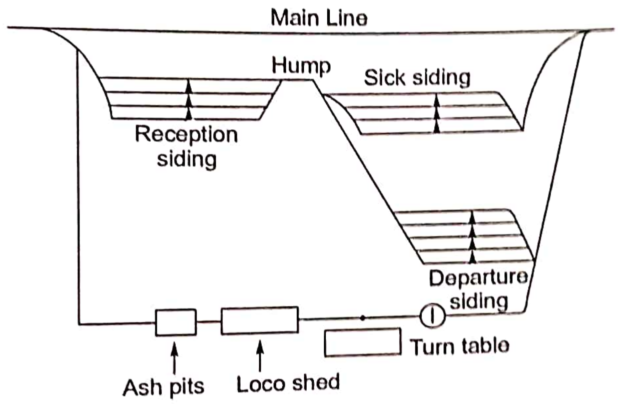
The important functions of a marshalling yard are as follows:

(i) Reception, (ii) Sorting, (iii) Departure

Sidings for each function or combination of two or combination of all three functions are provided. Thus various sidings like reception siding, sorting siding and departure siding are provided in the marshalling yards. Separate sets of sidings are provided for marshalling of wagons in up and down directions.

For efficient functioning of a marshalling yard the through trains should be dealt properly, i.e., shunting operations should not interfere with the time table or regular trains. The marshalling yard should be provided with all the facilities to place and withdraw wagons from various points in the local area. Marshalling yards should be constructed at all important junctions and particularly on stations where main routes are converging.

Marshalling yards can be classified into flat yards, gravitational yards and hump yards.



Q.6 What special measures and precautions are required in geometric features of a modern railway track?

[10 marks : 1999]

Solution:

Special measures required in geometric features of a modern railway track are:

(i) **Gauge of track:** A wider, correct and uniform gauge is desirable for attaining high speeds. Always wider is the gauge better would be the stability and hence higher the speed. The gauge over crossings is kept 1 mm tight to improve running. The gauge should be laid and maintained tight by 3 mm on straight and on curves upto 4 mm for high speed routes.

(ii) **Alignment of track:** For high speed tracks, both horizontal and vertical alignment should be perfect. For horizontal alignment, the flat curves along with transition curves and adequate super elevation should be provided. The sharp curves in tracks should either be eliminated by diverting the track or replacing them by flat curves. For vertical alignment, the steep gradients should be eliminated either by replacing them by gentle gradients or again by diverting the track or tunnelling through hills. Adequate cant deficiency should be provided.

(iii) **Other geometric elements:** Other geometric elements like cant, radius of the curve, degree of the curve, length of transition curve, etc., for high speeds should be provided.

(iv) **Track centres:** The centre to centre distance between tracks in station yards is kept more for high speeds tracks as compared to a section between stations. This offers several advantages such as safety of staff, elimination of problems of loading gauge and safety margin and possibility of allowing trains at high speeds over crossovers to greater intermediate track length.

Precautions required are as follows:

(i) Maintenance of track shall be within permanent tolerances.

(ii) Rails shall be ultrasonically tested at least once in two years for detecting cracks or flaws.

(iii) All critical points, such as points and crossings, vicinity of water columns, old rails over 10 years, portions with past history of rail breakage etc., shall be tested more frequently.

(iv) After one year of the train introduction, track irregularities shall be recorded once in two months and recording by oscillograph car atleast once in four months.

(v) There must not be less than (M + 3) effective sleepers for 13 m rail length (BG track) on the entire rate where M is length of rail in metres.

Q.7 Explain the function and working of a Floating Dry Dock with a neat sketch.

[10 marks : 1999]

Or

Explain giving a neat sketch, the use and working of a Floating Dry Dock.

[10 marks : 2002]

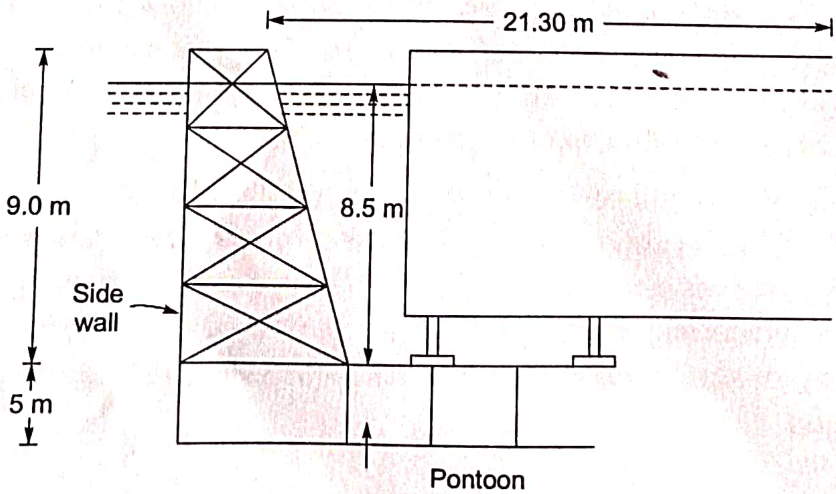
Solution:

Floating dry dock may be defined as a floating vessel which can lift a ship out of water and retain it above water by means of its own buoyancy. It is a hollow structure of steel or reinforced cement concrete consisting of 2 side walls and a floor, with the ends open. To receive a ship, the structure is sunk to required depth by ballasting its interior chambers with water, the ship is then floated into position and berthed. The dock is raised bodily with the berthed ship by unballasting the chambers by pumping out the water.

There are three important types of floating docks that have been developed viz. Rigid type floating docks, self docking type floating docks and self docking offshore type floating docks.

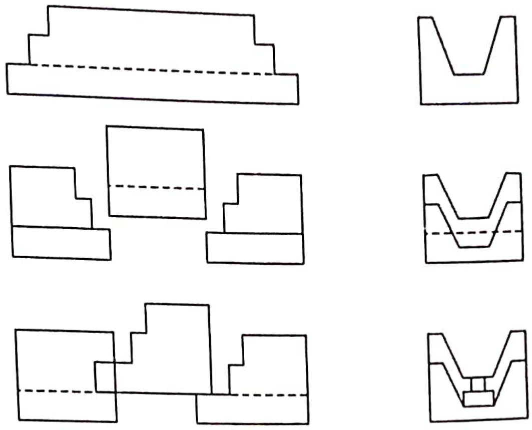
(i) Rigid type floating dry docks:

In this type, the side walls are rigidly fixed to the pontoon or bottom section. The floor portion is divided into a number of chambers, so as to assist in canting the dock if necessary to berth damaged ships, by partial unballasting of the chambers.



(ii) Self docking type floating docks:

Self docking refers to a type of floating dock, which is divided into sections longitudinally, and one of which is capable of being lifted and docked on the remainder of the dock for purposes of cleaning, painting or repairing. A typical self docking dry dock known as bolted sectional type is shown below:

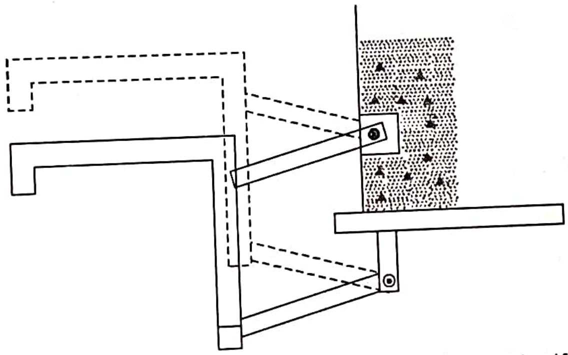


Firstly the whole dock (having minimum three sections) is shown assembled; secondly the centre section is shown detached and about to be docked on the two end sections and thirdly an end section is seen being docked on the other two.

This type is usually constructed in three equal sections, the two end sections having stepped ends to form landings during self docking. It combines the advantages of strength of the rigid type with self docking facility.

(iii) Self docking offshore type floating docks:

The offshore type floating dock has no side wall on the water side and has an L-shaped cross section. The side wall is connected to the shore by hinged parallel body capable of lifting or lowering the dock. The ship to be docked, could be brought on to the dock from either end or side ways.



The dock is longitudinally made into two sections, so as to dock one half on the other. The dock and the self docking operation are illustrated in the figure. This type of dock is convenient in a sheltered situation and adoptable for being attached to river quays.

Q.8 Enumerate the various types of track junction in use. Discuss the suitability of each under different conditions. **[15 marks : 2000]**

Solution:

The common track junctions are as follows:

(i) Turnouts: This is the simplest combination of points and crossings. These provide facilities for turning of trains from one track to another. One turnout provides facilities for turning of vehicles or trains in one direction of the main track only. Depending upon the facilities provided for turning on right or left of main track, the turnouts are called right hand or left hand turnouts respectively.

(ii) **Symmetrical Split:** When a turnout is taken off from a curved track, it is termed as a split. When a straight track is split up in two different directions with equal radii, it is known as a symmetrical split. This provides facilities for turning of trains in both left and right directions of the main track. It is suitable for locations where turnout from a straight track would take too much of space.

(iii) **Three throw switches:** When two turnouts take off from the same point of a main straight track, it is called "Three throw" arrangement. Three throw switches may be used in congested areas where space is not enough and heavy traffic is not prevailing such as goods yards, entrances to locomotives yards, etc. This track junction is obsolete these days.

(iv) **Double turnout:** This arrangement is an improvement over three throw switch. This can be used on main lines with heavy traffic and are of special significance in the congested areas where economic consideration in space is of primary importance.

(v) **Diamond crossing:** When straight tracks or curved tracks of the same or different gauges cross each other at an angle less than 90°, a diamond shape is formed, so this crossing is called diamond crossing. They are provided on straight tracks only as they necessitate restriction on speed.

(vi) **Crossovers:** When two adjacent parallel and diverging tracks, which may be straight or curved, are connected by two sets of turnouts, with or without a straight length between them, the connecting line is a crossover. These are useful to change the track, when trains are approaching from one direction only.

(vii) **Single slip and double slip:** In a diamond crossing two tracks cross each other but the trains cannot be taken from one track to another but in slip arrangement the trains can move from one track to another.

(viii) **Gauntlet track and fixed point system:** Gauntlet track is that arrangement of the track which is adopted when a double track is to be narrowed over a short distance of the track. This is used to economize the cost of a double line bridge. This is also used when part of a double line bridge is under repair.

(ix) **Scissor cross over:** It is a combination of one crossover over the other cross over in the opposite direction to enable the trains to change the track from either direction along the main track. This arrangement is useful where enough space for two separat cross overs is not available and shunting operations are frequent.

(x) **Gathering lines or ladder tracks:** When a number of parallel tracks are branched off from the straight track in continuation of a turnout, it is called a gathering line or ladder track. This arrangement is known as "Herring bone Grid" and is used in marshalling yards and goods yards where sidings are almost of equal length.

(xi) **Temporary diversion:** A temporary diversion is required when the track has to be directed from its original position if some heavy or time consuming work required is to be done on original track or track has failed under floods etc.

(xii) **Triangle:** The triangles are required to change the direction of engines. Turn tables are also used to change the direction of engines but they are very costly. So, if enough area is available and railway sections are not important, then the installation of a turn table is not justified.

(xiii) **Double junctions:** These junctions become essential where two or more main tracks are running and where branches are taking off from main tracks.

Q.9 What are the functions of Railway Stations? Describe the factors that influence the selection of site for a railway station.

[10 marks : 2000]

Solution:

The need for air traffic control is mainly for two reasons. Firstly to safeguard life and property and secondly to expedite the traffic movements. The control of air traffic deals with that phase of air transportation which ensures safe, convenient and economic movement of aircraft from one airport to another airport. The aircraft flight from one airport to another involves the following basic actions:

(i) The aircraft takes off from an airport
(ii) It maintains a proper altitude in air
(iii) It navigates from point to point safely
(iv) It lands at the desired airport

The primary functions of air traffic control devices can therefore be summarised as follows:

Airport traffic control:

This deals with the following:

(i) To guide the aircraft, desiring to land or take off
(ii) To control the taxing of arriving and departing aircraft on the airfield between the apron and the runway.

Airway traffic control:

This regulates the movement of aircraft along the air routes with adequate lateral and vertical separation to avoid collision. This is particularly essential when visibility is poor.

Airway communication:

This deals with conveying of airway and weather information to the pilot during the flight.

General or non-airway traffic control:

This presents a serious problem when personal flying is done by a large number of people. In such cases the movement of aircraft, not flying along the airway must be regulated to prevent interference to the main air traffic.

Various enroute aids are available to the pilot during his flight from one airport to another. They are as follows:

(i) Airway beacon
(ii) Low/Medium frequency (LF/MF) ratio range
(iii) Very high frequency omnidirectional range (VOR)
(iv) Air ground communication
(v) Tactical air navigation (TACAN)
(vi) Distance measuring equipment (DME)
(vii) Marker beacon
(viii) Direction finder
(ix) Air route surveillance radar (ARSR)

The following aids are available to any aircraft while landing:

(i) Instrument landing system (ILS)
(ii) Precision approach radar (PAR) or Ground approach control (GAC)
(iii) Airport surveillance radar (ASR)
(iv) Airport surface detection equipment (ASDE)
(v) Approach lights

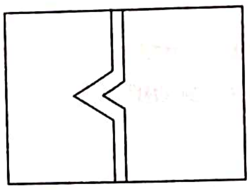
Q.11 Enumerate the forces acting on an upright wall breakwater and explain their destructive effects.
[10 marks : 2000]

Solution:

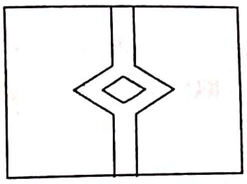
The forces acting on an upright wall break water are:

1. **Shearing of bed joints due to horizontal pressure of the wave** : This can be prevented by the adhesive force of the mortar joint and frictional resistance.

2. **Overturning due to horizontal pressure of wave :** This is another aspect of the horizontal pressure and the design should provide for this like ordinary walls to keep the resultant of the weight and the horizontal pressure within the third of the base to avoid tension cracks in the foundation courses.
3. **Uplift force :** This force is generated by difference in water levels between outside and inside of harbour basin. The only force to eliminate this is the weight of the masonry.
4. **Fracture :** This does not result directly from water action. It may be caused by the dislocated blocks knocking against each other and breaking loose the joint. Such failures are usually avoided by proper binding in the masonry by joggles, etc.



Joggle Joint



Dowel Joint

Q.12 (i) Define and explain the term "Breathing length of LWR".
(ii) Determine the minimum theoretical length of LWR beyond which the central portion of 52 kg rail would not be subjected to longitudinal movement due to 30°C temperature variation. Use the following additional data:
(a) RAIL :
- **50 kg rail section**
- **Cross sectional area = 66.15 cm²**
- **Modulus of elasticity of rail section = 2.1 x 10⁶ kg/cm²**
- **Coefficient of thermal expansion of rail section = 11.5 x 10⁻⁶/°C**

(b) SLEEPER :
- **Sleeper spacing = 60 cm**
- **Average resisting force/sleeper/rail = 300 kg**

[15 marks : 2001]

Solution:

(i) A long welded rail continues to expand at its ends for a particular length till adequate forces gets developed towards the centre. A stage reaches when at a particular length of the rail from its ends, the resistance offered by the track structure accumulates and becomes equal to thermal forces created as a result of changes in temperature. There is no movement of rail beyond this point. The cumulative value of expansion or contraction of these portions of the rail at the ends (breathing length) is given by

$$\delta L = \frac{L\alpha t}{2}$$

where L is length of the portion of rail, α is coefficient of thermal expansion of rail and t is variation in temperature

Thus, the portion of the long welded rail in the end, which undergoes movement due to temperature variations, and absence of resisting forces of track is called the breathing length.

(ii) Suppose L is the length of rail required, then

$$\delta L = L\alpha t$$

$$\therefore \quad \text{Strain prevented} = \frac{\delta L}{L} = \frac{L\alpha t}{L} = \alpha t$$

Given that $\alpha = 11.5 \times 10^{-6}/°C$ and $t = 30°C$

$\therefore$ Strain prevented $= 11.5 \times 10^{-6} \times 30 = 345 \times 10^{-6} = 3.45 \times 10^{-4}$

$\therefore$ Stress developed $=$ Strain prevented $\times E = 3.45 \times 10^{-4} \times 2.1 \times 10^{6} = 724.5$ kg/cm²

$\therefore$ Force developed $=$ Stress developed $\times$ Cross sectional area of rail

$= 724.5 \times 66.15 = 47925.675$ kg

Given that average resisting force per sleeper per rail = 300 kg

∴ Number of sleepers required to prevent the force developed,

$$n = \frac{\text{Force developed}}{\text{Average resisting force per sleeper}} = \frac{47925.675}{300}$$

$$= 159.75 \approx 160 \text{ (approx.)}$$

Given that sleeper spacing = 60 cm (say S)

We know that minimum length of welded rail $= (n - 1)\, S = (160 - 1) \times 60 \times 10^{-2} = 95.4$ m

Q.13 What are the requirement of an ideal permanent way? Draw a dimensional cross section of a *BG* track in embankment on a straight track and mark the details.

[10 marks : 2002]

Solution:

Permanent track is regarded to be semi-elastic in nature. There is possibility of track getting disturbed by the moving wheel loads. The track should therefore, be constructed and maintained keeping the requirements of a permanent way, in view, so as to achieve higher speed and better riding qualities with less future maintenance. Following are some of the basic requirements of a permanent way:

(i) The gauge should be correct and uniform.

(ii) The rails should be in proper level. Thus in a straight track, two rails must be at the same level. On curves, the outer rail should have proper super elevation and there should be proper transition at the junction of a straight and a curve.

(iii) The alignment should be correct, i.e. it should be free from kinks or irregularities.

(iv) The gradient should be uniform and as gentle as possible. Any change of gradient should be followed by a smooth vertical curve to give smooth riding quality.

(v) The track should be resilient and elastic in order to absorb shocks and vibrations of running track.

(vi) The track should have enough lateral strength, so that alignment is maintained even due to effects of side thrust on tangent lengths and centrifugal forces on curves.

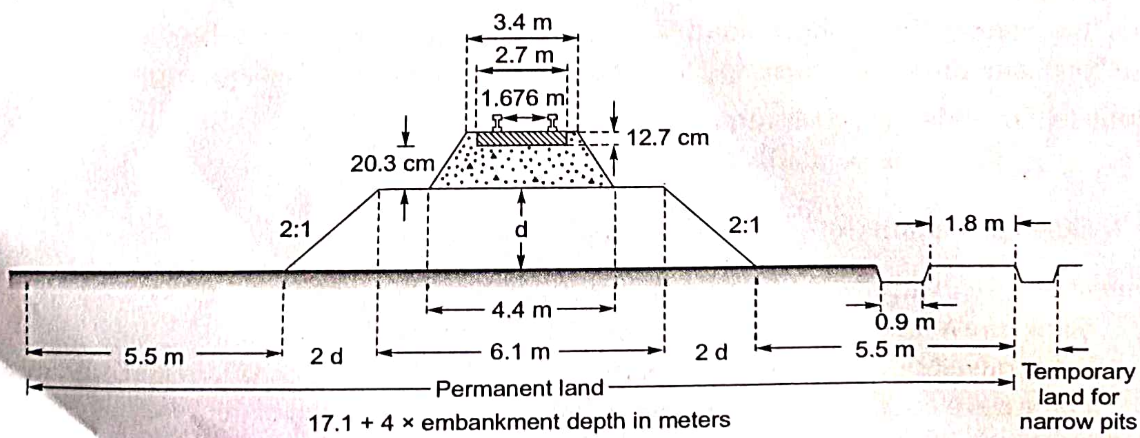
(vii) The radii and super elevation on curves should be properly designed and maintained.

(viii) Drainage system must be perfect for enhancing safety and durability of track.

(ix) Joints including points and crossings which are regarded to be weakest points of the railway track, should be properly designed and maintained.

(x) The track structure should be strong, low in initial cost as well as maintenance cost.

The typical cross section of BG track in embankment on straight track is shown below:



Q.14 For a broad gauge track in a transition zone, in order to allow locomotives with a maximum permissible speed of 110 kmph, calculate the following:
(i) Radius of curvature (ii) Degree of curvature (iii) Super elevation (iv) Length of transition
[10 marks : 2003]

Solution:
We know that, by Martin's formula for a *BG* track in a transition zone for speed > 100 kmph

$$V = 4.58\sqrt{R}$$

where V is maximum permissible speed in kmph and R is radius of curvature in meters

Now, $V = 110$ kmph (given)

$$110 = 4.58\sqrt{R}$$

$\therefore$ $R = 576.84$ m

$\Rightarrow$ Degree of curvature is given as

$$\frac{2\pi R}{360} = \frac{30}{D}$$

$$D = 2.98^\circ \approx 3^\circ$$

$\therefore$ $D = 3^\circ$,

For

$$R = \frac{1718.9}{D^\circ} = \frac{1718.9}{3^\circ} = 573 \text{ m}$$

Theoretical superelevation is given by

$$e_{th} = \frac{GV^2}{127R}$$ where G = Gauge distance

$$= \frac{(1.676\times100)\times110^2}{127\times573} = 27.868 \text{ cm}$$

Now, maximum cant deficiency, $D_{max} = 10$ cm

$\therefore$ actual superelevation,

$$e_{act} = e_{th} - D_{max}$$

$$= 27.868 - 10 = 17.868 \text{ cm}$$ (> 16.5 cm as V < 120 kmph) Not OK

$\therefore$ now use Degree of curvature, $D = 2^\circ$

Radius of curvature is,

$$\frac{2\pi R}{360^\circ} = \frac{30}{D}$$

$\therefore$ $R = 860$ m

Now, theoretical superelevation is given as,

$$e_{th} = \frac{GV^2}{127R} = \frac{(1.676\times100)\times110^2}{127\times860}$$

$$e_{th} = 18.567 \text{ cm}$$

Length of transition curve, L = ?

(i) $L = 4.4\sqrt{R} = 4.4\sqrt{860} = 129.03\text{m}$

(ii) $L = 3.6e_{act} = 3.6\times8.567 = 30.84\text{m}$

(iii) $L = \frac{V^3}{CR} = \frac{\left(110\times\frac{5}{18}\right)^3}{0.3048\times860} = 108.832\text{m}$

Thus, length of transition curve = 129.03 ≈ 130 m
(maximum of above 3).

Q.15 What is the equilibrium cant required on a 5° curve on a *BG* track for the train speed of 60 kmph? [10 marks : 2004]

Solution:

Degree of curvature of curve, $D = 5^{\circ}$

For a *BG* track, $G = 1.676\text{ m}$

Speed of train $V = 60\text{ kmph}$

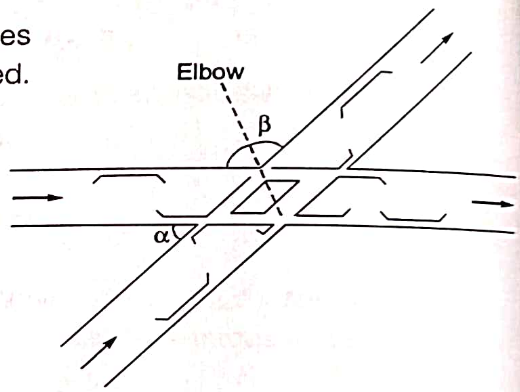
Radius of curvature, $R = \dfrac{1718.9}{D} = \dfrac{1718.9}{5} = 343.78\text{ m}$

Super elevation, $e = \dfrac{GV^2}{127R} = \dfrac{1.676 \times (60)^2}{127 \times 343.78} = 0.1382\text{ m} = 13.82\text{ cm}$

Q.16 What is diamond crossing on a railway track? Give a sketch of such crossing for a *BG* track. Explain the salient features of different parts of the crossing.

[10 marks : 2004]

Solution:



When straight tracks or curved tracks of the same or different gauges cross each other at an angle less than 90°, a diamond shape is formed. So this crossing is called a diamond crossing.

The salient features of diamond crossing are:

(i) It consists of two acute angle crossings (α and α) and two obtuse angle crossings (β and β) and four check rails.

(ii) The length of the gap between two noses of an obtuse crossing increases as the acute angle of crossing decreases.

(iii) Indian Standards specify the limit of flattest diamond to be 1 in 10 for *BG* tracks and 1 in 8.5 for other tracks. Crossing of tracks at sharper angles to this limit is undesirable.

(iv) Diamond crossings should be avoided as far as possible on curves as they necessitate restriction on speed.

Q.17 What is the importance of track drainage? State the measures to be adopted with suitable illustrations. [10 marks : 2004]

Solution:

The bearing power (or strength and stability of soil i.e. resistance to shear of soils) are greatly reduced due to presence of excess moisture. The variation in bearing strength and stability depends upon the percentage of moisture, soil type and mode of stress application. Track drainage is important due to following reasons:

(i) The modern-track embankments, which are subjected to heavy and fast loads, get settled due to presence of excess moisture.

(ii) The presence of excess sub-surface moisture reduces the track stability and results in ballast pockets, dirty ballast, low joints pumping sleepers, unstable formation and slipping and subsiding banks.

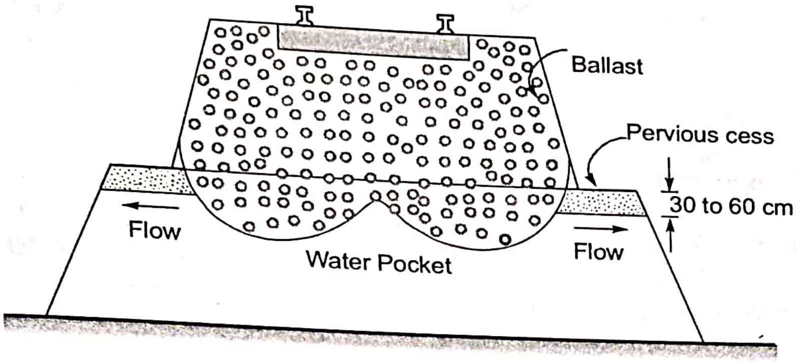
(iii) The presence of surface water and ground water if not properly drained results in recurrent soft spots, unstable banks and cuttings, bank slips and land slides.

(iv) The erosion of soil from the bank, slopes of embankment, cut and hill side is caused due to surface water.

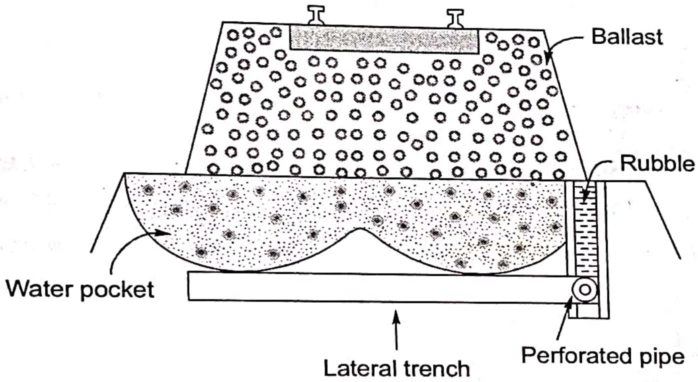
(v) In the rainy season, the presence of a badly drained track formation is the main cause of accidents due to derailments.

The following remedial measures can be adopted to prevent sinking of ballast into wet soil:

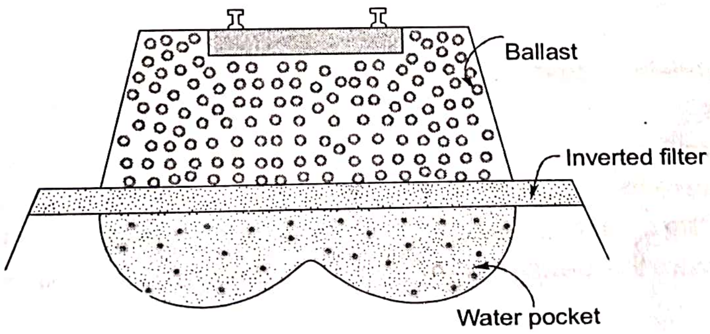
(i) **Use of pervious cess:** If trouble in track performance due to formation of water pocket is not excessive, in such cases pervious cess can be provided as shown in figure.



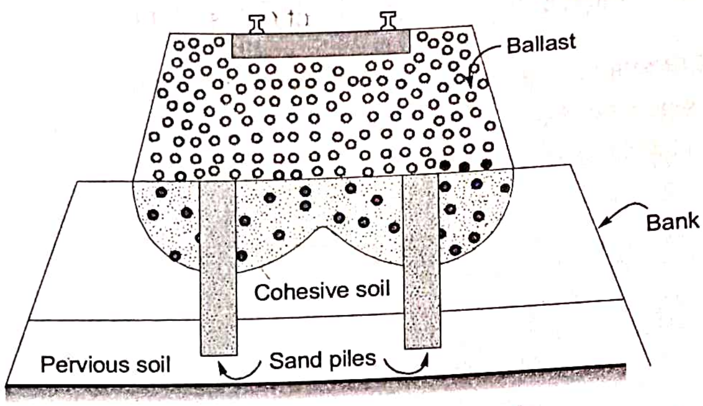
(ii) **Use of perforated pipes and trench drains:** Water can also be successfully drained by use of perforated pipes and trench drains. These perforated pipes are laid with loose joints so that water which surrounds them can enter inside after it has seeped to the rubble filled trench.



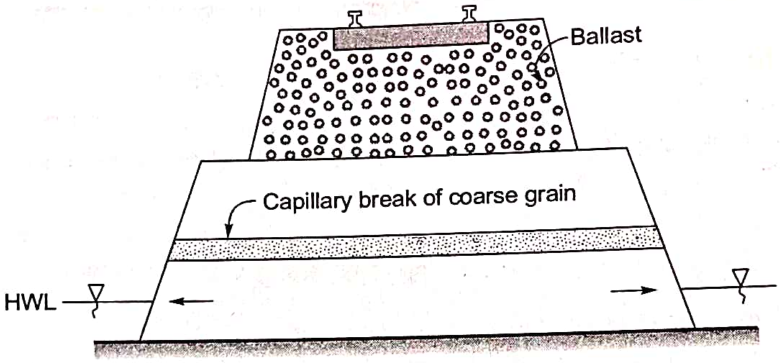
(iii) **Use of inverted filter blanket:** If water pocket formation causes excessive trouble then the method is to first screen the ballast, drain off water pockets and then provide 20 cm to 30 cm thick inverted filter blanket.



(iv) **Use of sand piles:** In case a pervious soil strata is existing below cohesive soil, the sand piles can be used. Water pocket is formed in cohesive soil and water from it can be collected in the sand piles which further passes it to pervious layer and formation gets stabilized.



(v) **Use of capillary break:** If the trouble of water pocket is caused due to capillary use, then capillary break is the best remedy. But use of capillary break in embankment is not possible when embankment is built. So while constructing formation this should be borne in mind.



Q.18 State the reasons due to which the vertical, horizontal and transverse loadings are caused to the sleepers in a railway track. Why is ballast filled between the sleepers? Write the merits and demerits of concrete sleepers and explain the reasons of these being extensively used in India.

[10 marks : 2006]

Solution:

Some of the reasons due to which the vertical, horizontal and transverse loadings (stresses are caused to the sleepers in a railway track are:

(i) Wheel load
(ii) Weight transfer from wheel to wheel on the same and different axles.
(iii) Irregularities of the rails
(iv) Speed
(v) Dynamic effect of wheels on rails
(vi) Elasticity of the rails
(vii) Efficiency of fastenings
(viii) Longitudinal forces in rails

Ballast is filled between the sleepers because it performs the following functions:

(i) It transfers the load from the sleeper to the subgrade and then distributes it uniformly over a larger area of the formation.
(ii) It holds the sleepers in position and prevents the lateral and longitudinal movement, due to dynamic loads and vibrations of moving trains.
(iii) It imparts some degree of elasticity to the track.

(iv) It provides easy means of maintaining the correct levels of the two lines of a track and for correcting track alignment.

(v) It provides good drained foundation immediately below the sleepers and helps to protect the top surface of the formation. This is achieved by providing coarse and rough aggregates with plenty of voids.

Merits of Concrete Sleepers:

(i) These sleepers are free from natural decay and attacks by vermin, insects, etc.

(ii) They have maximum life when compared to other sleepers, the life under normal conditions is 40 to 60 years.

(iii) These are not affected by moisture, chemical action of ballast, cinder and subsoil salt.

(iv) These have higher elastic modulus and hence can withstand the stresses induced by fast and heavy traffic.

(v) Concrete sleepers in the elastic fastenings offers an ideal track in respect of gauge, cross level and alignment.

Demerits of Concrete Sleepers:

(i) The weight of concrete sleeper is as high as 2.5 to 3 times of wooden sleeper, requiring the mechanical appliances for handling.

(ii) These sleepers require pads and plugs for spikes.

(iii) They damage the bottom edge during the packing.

(iv) The scrap value is almost nil.

(v) The damages to the concrete sleepers is very heavy in case of derailment.

Q.19 Define cant and cant deficiency. Calculate the length of the transition curve for a broad gauge curved track having 5° deflection and a cant of 14 cm. The maximum permissible speed on the curved track is 80 kmph.

[9 marks : 2007]

Solution:

When a train moves round a curve, it is subjected to a centrifugal force acting horizontally at the centre of gravity of each vehicle radially away from the centre of the curve. This increases the weight on the outer rail. To counteract the effect of centrifugal force, the level of the outer rail is raised above the inner rail by a certain amount to introduce the centripetal force. This raised elevation of outer rail above the inner rail at a horizontal curve is called super elevation or cant.

Cant deficiency is the difference between the equilibrium cant necessary for the maximum permissible speed on a curve and the actual cant provided on the basis of average speed of trains.

Indian railways specify that greatest of the following lengths should be taken as length of the transition curve:

(i) $L = 7.20 \times e$

$e = 14$ cm (given)

∴ $L = 7.20 \times 14 = 100.8$ m

(ii) $L = 0.073\, D \times V_{max}$

where D is cant deficiency in cm

For BG tracks and for speeds up to 100 kmph, $D = 7.6$ cm

$V_{max} = 80$ kmph (given)

∴ $L = 0.073 \times 7.6 \times 80 = 44.38$ m

(iii) $L = 0.073\, e \times V_{max} = 0.073 \times 14 \times 80 = 81.76$ m

Hence the length of the transition curve is taken as 100.8 m.

Q.20 **Design the length of a transition curve for a BG railway curved track having 4° deflection and a 'cant' of 12 cm. The maximum design speed on the curve is 100 kmph. Also calculate offsets at every 15 m intervals and shift of the circular curve. Assume the cant deficiency as 7.6 cm.**

[10 marks : 2008]

Solution:

As per Indian Railways the length of the transition curve is the greater out of the following three values

(i) $L = 7.20 \times e = 7.20 \times 12 = 86.4$ m

(ii) $L = 0.073\, D \times V_{max} = 0.73\, D \times 7.6 \times 100 = 55.48$ m

(iii) $L = 0.073\, e \times V_{max} = 0.073 \times 12 \times 100 = 87.6 \text{ m} \approx 88$ m

Hence length of curve is to be taken as 88 m.

Now, $L = 90$ m (say)

The equation of cubic parabola which is used as a transition curve is given by

$$y = \frac{x^3}{6RL}$$

But
$$R = \frac{1720}{\text{Degree of curve}} = \frac{1720}{40} = 430 \text{ m}$$

Taking offsets at 15 m intervals, we get

$$y_{15} = \frac{(15)^3 \times 100}{6 \times 430 \times 90} = 1.45 \text{ cm}$$

$$y_{30} = \frac{(30)^3 \times 100}{6 \times 430 \times 90} = 11.63 \text{ cm}$$

$$y_{45} = \frac{(45)^3 \times 100}{6 \times 430 \times 90} = 39.24 \text{ cm}$$

$$y_{60} = \frac{(60)^3 \times 100}{6 \times 430 \times 90} = 93.02 \text{ cm}$$

$$y_{75} = \frac{(75)^3 \times 100}{6 \times 430 \times 90} = 181.69 \text{ cm}$$

$$y_{90} = \frac{(90)^3 \times 100}{6 \times 430 \times 90} = 313.95 \text{ cm}$$

Chainage (m)	15	30	45	60	75	90
Offset (cm)	1.45	11.63	39.24	93.02	181.69	313.95

Shift of the curve,
$$S = \frac{L^2}{24R} = \frac{(90)^2}{24 \times 430} = 0.785 \text{ m}$$

Q.21 **Enumerate and explain all possible factors which are to be assessed precisely and to be taken into account during the process of decision making for suitability of a potential site for a Civilian Airport.**

[10 marks : 2008]

Solution:

The factors listed below are for the selection of a suitable site for a major civilian airport installation:

(i) **Regional plan:** The site selected should fit well into the regional plan, thereby forming it an integral part of the national network of airport.

Q.22 Determine the length of transition curve and offsets at every 15 metres for BG curved track having 4° curvature and cant of 12 cm. The maximum permissible speed on curve is 85 kmph.

[10 marks : 2009]

Solution:

Indian Railways specify that greatest of the following lengths should be taken as length of the transition curve:

(i)
$$L = 7.20 \times e \text{ where e is cant in cm}$$
$$\therefore \quad L = 7.20 \times 12 = 86.4 \text{ m}$$

(ii)
$$L = 0.073\, D \times V_{max}$$

where D is cant deficiency in cm and V_{max} is maximum permissible speed on the curve.

For BG tracks and for speeds upto 100 kmph, $D = 7.6$ cm

$$V_{max} = 85 \text{ kmph} \quad \text{(given)}$$
$$\therefore \quad L = 0.073 \times 7.6 \times 85 = 47.158 \text{ m}$$

(iii) $L = 0.073\, e \times V_{max} = 0.073 \times 12 \times 85 = 74.46$ m

Hence the length of transition curve is 86.4 m, but it is taken as 90 m (being multiple of chain length).

Radius of curve, $$R = \frac{1720}{D} = \frac{1720}{4} = 430 \text{ m}$$

The equation of cubic parabola is

$$y = \frac{x^3}{6RL}$$

$$\text{Offset at 15 m} = \frac{(15)^3}{6 \times 430 \times 90} \times 100 = 1.45 \text{ cm}$$

$$\text{Offset at 30 m} = \frac{(30)^3}{6 \times 430 \times 90} \times 100 = 11.63 \text{ cm}$$

$$\text{Offset at 45 m} = \frac{(45)^3}{6 \times 430 \times 90} \times 100 = 39.24 \text{ cm}$$

$$\text{Offset at 60 m} = \frac{(60)^3}{6 \times 430 \times 90} \times 100 = 93.02 \text{ cm}$$

$$\text{Offset at 75 m} = \frac{(75)^3}{6 \times 430 \times 90} \times 100 = 181.69 \text{ cm}$$

$$\text{Offset at 90 m} = \frac{(90)^3}{6 \times 430 \times 90} \times 100 = 313.95 \text{ cm}$$

Chainage (m)	15	30	45	60	75	90
Offset (cm)	1.45	11.63	39.24	93.02	181.69	313.95

Q.23 What are the assumed conditions of runway length for standard environment which decide the basic runway length?

[5 marks : 2009]

Solution:

The assumed conditions at the airport are as follows:

(i) Airport altitude is at sea level.

(ii) Temperature at the airport is standard (15°C).

(iii) Runway is levelled in the longitudinal direction.
(iv) No wind is blowing on runway.
(v) Aircraft is loaded to its full loading capacity.
(vi) There is no wind blowing enroute to the destination.
(vii) Enroute temperature is standard.

Q.24 Determine the actual runway length after applying necessary corrections for elevation and temperature as per ICAO and gradient correction as per FAA specification for the data given below.
(i) Basic runway length = 1800 metres
(ii) Elevation of airport site = 600 metres
(iii) Monthly mean of average daily temperature for the hottest month of the year = 15°C
(iv) Monthly mean of maximum daily temperature for the same month = 21.6°C
(v) Effective gradient = 0.6%

[5 marks : 2009]

Solution:

(i) Correction for elevation:

ICAO recommends that the basic runway length should be increased at the rate of 7 percent per 300 m rise in elevation above mean sea level.

$$\therefore \quad \text{Correction for elevation} = \frac{7}{100} \times 1800 \times \frac{600}{300} = 252 \text{ m}$$

$$\text{Thus,} \quad \text{Corrected length} = 1800 + 252 = 2052 \text{ m}$$

(ii) Correction for temperature:

Standard atmospheric temperature at the given elevation = $15° - 0.0065 \times 600 = 11.1°C$

$$\text{Airport reference temperature} = T_a + \frac{T_m - T_a}{3} = 15° + \frac{21.6° - 15°}{3} = 17.2°C$$

As per ICAO the basic runway length after having been corrected for elevation should be further increased at the rate of 1% for every 1°C rise of airport reference temperature.

Rise in temperature = $17.2 - 11.1 = 6.1°C$

$$\text{Correction for temperature} = 2052 \times \frac{1}{100} \times 6.1 = 125.172 \text{ m}$$

Thus, corrected length = $2052 + 125.172 = 2177.172$ m

Check for the total correction for elevation plus temperature:

$$\text{Total correction in percentage} = \frac{2177.172 - 1800}{1800} \times 100 = 20.95\%$$

As per ICAO, the total correction for elevation plus temperature should not exceed 35% of the basic runway length.

(iii) Correction for gradient:

FAA recommends that the runway length after having been corrected for elevation and temperature should be further increased at the rate of 20% for every 1% of effective gradient.

$$\text{Correction for gradient} = \frac{20}{100} \times 2177.172 \times 0.6 = 261.261 \text{ m}$$

Thus, corrected length = $2177.172 + 261 = 2438.433$ m

Rounding the above value to the nearest 10 m, the corrected runway length is 2440 m.

Q.25 **A BG track has a sleeper density of n + 6. If the track is laid with welded rails of 26 m length, find out the number of sleepers required for constructing a railway track of 1690 m.**

[2 marks : 2010]

Solution:

$$\text{Length of each rail,} \quad n = \frac{26}{2} = 13\text{ m}$$

$$\text{Sleeper density} = n + 6 = 13 + 6 = 19$$

$$\text{Total number of rails required} = \frac{1690}{13} = 130$$

$$\therefore \quad \text{Total number of sleepers} = \text{Number of rails} \times \text{Sleeper density} = 130 \times 19 = 2470$$

Q.26 **A locomotive on BG track with four pairs of driving wheels each carrying axle load of 20 tonnes is required to haul a train at a speed of 80 kmph. The train is made to run on a level track with curvature of 2°. Calculate the maximum permissible load that can be pulled by the engine. Take hauling capacity as one-sixth of the load on driving wheels.**

[8 marks : 2010]

Solution:

Hauling capacity of locomotive, $H = \frac{1}{6} \times \text{load on driving wheels} = \frac{1}{6} \times 4 \times 20 = \frac{40}{3}$ tonnes

On a curved level track, train resistance is given by

$$T = 0.0016\,\text{W} + 0.00008\,\text{WV} + 0.0000006\,WV^2 + 0.0004\,\text{WD}$$

where W is weight of train in tonnes including weight of locomotive, V is speed of train in kmph and D is degree of curve.

$$\therefore \quad T = 0.0016\,W + 0.00008\,W \times 80 + 0.0000006\,W \times (80)^2 + 0.0004\,W \times 2$$

$$\Rightarrow \quad T = 0.01264\,W$$

But, Hauling capacity = Train resistance

$$\Rightarrow \quad H = T$$

$$\Rightarrow \quad \frac{40}{3} = 0.01264\,W$$

$$\Rightarrow \quad W = 1054.85$$

$$\Rightarrow \quad W \approx 1055 \text{ tonnes}$$

Q.27 **Determine the radius of a taxiway for a supersonic aircraft to negotiate the curve at a turning speed of 50 kmph. The wheel base is 35 m and the tread of main landing gear is 7.5 m. The airport is of type A as per ICAO. Assume coefficient of friction between tyre and pavement surface as 0.13.**

[8 marks : 2010]

Solution:

Turning speed, $V = 50$ kmph
Wheel base of aircraft, $W = 35$ m
Tread of main landing gear = 7.5 m
Coefficient of friction between tyre and pavement surface, $f = 0.13$
For type A airport as per ICAO width of taxiway, $T = 22.5$ m

(i) Turning radius may be expressed as

$$R = \frac{V^2}{125 f} = \frac{(50)^2}{125 \times 0.13} = 153.85 \text{ m}$$

Q.35 Discuss the cause and effects of "Creep of Rails".

Solution: [4 marks : 2013]

Creep of Rails: Creep of rails is the longitudinal movement of rails of the track in the direction of motion of locomotives. Creep is common to all railways and value of creep ranges from zero to about 6 inches or 16 cm.

Causes of Creep:

(i) Unequal contraction and expansion of rails due to variation in temperatures give rise to creep.

(ii) Creep develops in rails when a train starts on stops. While starting, train pushes the rail backwards and while stopping due to application of brakes, creep in rails occur in forward direction.

Effects of Creep of Rails:

(i) The most serious effect of creep is the buckling of track in lateral directions. If unattended and not properly removed them if causes derailments which leads to accident.

(ii) Sleepers move out of position which leads to the change in gauge and alignment of the track.

(iii) Rail joints are opened out of their limit in some case and stresses are set up in fish plates and bolts which leads to the breakage of the bolts.

(iv) Pints and crossing get disturbed.

(v) Maintenance and replacement of tracks become difficult.

(vi) Smashing of fish plates and bolts, bending of bars, kinks at joint are other effect of creep.

Q.36 What is a breakwater? Classify different types of breakwaters. Under what condition a rubble mound breakwater is preferred? [2 marks : 2013]

Solution:

Breakwater: This is a type of structure constructed on coast as a part of coastal defence, to protect the anchorages from the effect of sea.

Types of breakwater:

1. **Cairson breakwater:** These have vertical sides and use self weight and mass of fill within to resist the overturing forces by waves.
2. **Rubble mound breakwater:** They use structural voids to dissipitate the wave energy.

Q.37 Describe Beanfort Scale. [2 marks : 2013]

Solution:

Beanfort Scale: The original Beanfort scale doesnot represent the actual velocity with which the air moves. It is merely a scale of wind conditions that was used by sailors to categorize different sailing conditions. With increasing no. of type of sailing ships and eventually the arrival of steam boats, exchanging and comparing the wind force information became a problem. Attempts have been made to express the Beanfort scale nos. into physical units by cumulating the Beanfort nos. for wind force with measured speed by anemometers. There always exist the possibility to arrive at unexpected results while converting different anemometer readings i.e., knots as m/s to Beanfort numbers.

SOLVED NUMERICAL EXAMPLES

EXAMPLE 1. Derive the expression for sleeper density for a broad gauge track if 19 sleepers are used under a rail. Given that length of a rail for B.G. track is 12.8 metres. **(GATE 2007)**

Solution: Sleeper density = $n + x$

Where n is length of rail in metres

x is a factor depending upon several factors, axle load, section of rail, etc.

$$19 = 12.8 + x$$

∴ 12.8 may be rounded to 13

$$x = 19 - 13 = 6$$

Ans. Sleeper density is $n + 6$.

EXAMPLE 2. Using a sleeper density of $n + 5$, find out the number of sleepers required for constructing a broad gauge railway track of 0.64 km length.

Solution: Length of each rail on a B.G. track = 12.8 m

$$\text{Total number of rails required will be} = \frac{640}{12.8} = 50 \text{ rails}$$

Since sleeper density is $n + 5$

Number of sleepers under each rail

$$= 12.8 + 5 = 17.8 \text{ say } 18$$

total number of sleepers required

$$= 50 \times 18 = 900 \text{ sleepers}$$

Ans. Sleepers required are 900

EXAMPLE 3. Calculate the materials required to construct one kilometre long broad gauge railway track.

Data given: B.G. rail length = 12.8 m

weight of rail = 44.7 kg/m

density factor $x = 4$

Solution: The exact quantities of various materials required for one track are calculated as follows:

(*a*) Rails:

$$\text{Number of rails/km} = \frac{1000}{\text{length of rail in m}} \times 2$$

for B.G. rail length = 12.8 m

$$\therefore \text{Number of rails per km} = \frac{1000}{12.8} \times 2 = 156.2 \text{ say } 157$$

Also weight of rail per km

= (Number of rails × length of rail in m)

$$\times \frac{\text{weight of rail per m}}{1000} \text{ in tonnnes}$$

$$= \frac{157 \times 12.8 \times 44.7}{1000} = 90 \text{ metric tonnes}$$

(*b*) Sleepers:

Number of sleepers per km

$$= \frac{1}{2} \text{ (no. of rails per km) } (n + x)$$

where,

n = length of rail in m

x = density factor

$$\therefore \text{Number of sleeper per km} = \frac{157}{2}(12.8 + 4) = 1319$$

(*c*) Fish plates:

Number of fish plates per-km of track

= 2 × number of rails per km

Number of fish plates per km of track = 2 × 157 = 314

(*d*) Fish bolts:

Number of fish bolts per km, of track

= 4 × Number of rails per km

= 4 × 157 = 628

(*e*) Bearing plates:

Number of plate per km of track depends upon design

Number of bearing plates per km of track is either

= 2 × number of sleepers per km of track

= 2 × 1319 = 2638

or

= 4 × Number of rails per km of track

= 4 × 157 = 628

(*f*) Dog spikes:

For timber sleepers, number of dog spikes per km of track

= 4 ×Number of sleepers per km of track

= 4 × 1319 = 5276

Ans. (*i*) to (*vii*)

EXAMPLE 4. What should be the length of track (*i*) to overcome temp stress (*ii*) to prevent creep for equilibrium? It is given, $A = 60$ cm^2; $\alpha = 1.10 \times 10^{-5}$ per C; $E = 21.5 \times 10^5$ kg/cm^2 and rise in temp $t = 25$ °C. Assume resistance to track movement = 700 kg/km.

Solution: The force required to prevent expansion due to temperature is given by

$$F = \alpha\, t\, A.E$$

$$\therefore \quad F = \alpha\, E\, At$$

$$F = 1.10 \times 10^{-5} \times 21.5 \times 10^{-5} \times 60 \times 25$$

$$= 1.10 \times 21.5 \times 60 \times 25 = 35475 \text{ kg}$$

(*a*) Length of track required to overcome temp. stress

$$L_t = \frac{35475}{700} = 50.678 \text{ km}$$

(*b*) To prevent creep for equilibrium the length of welde track = 2 × L_t

= 2 × 50.678 = 101.356 km

Ans. (*i*) and (*ii*) abo

EXAMPLE 5. If a cross-over occurs between two paral BG track of some crossing number of 1 in 8 with strai intermediate portion between the reverse curve, and distance between centres of track is 5 m, find intermediate straight distance and the overall lengt cross-over. **(Civil Service Exam. 2(**

Solution: When crossing is equal and the intermediate poi of cross over is straight, then consider $N = 8$

$G = 1.676$ m

$D = 5$ m

The intermediate straight distance S is given by relation

$$S = (D - G)\,N - G\sqrt{1 + N^2}$$

$$S = (5 - 1.676)\,8 - 1.676\sqrt{1 + (8)^2}$$

$$= 3.324 \times 8 - 1.676 \times 8.062 = 13.08 \text{ m}$$

The overall length of cross over L is given by relation

$$L = 4\,GN + S$$

$$L = 4 \times 1.676 \times 8 + 13.08$$

$$= 53.532 + 13.08 = 66.712 \text{ m } \textbf{Ans.}$$

EXAMPLE 6. Calculate all the necessary elements required to set out a 1 in 8 turnout, taking off from a straight BG track with its curve starting from the toe of the switch *i.e.*, tangential to the gauge face of the outer main rail and passes through theoretical nose of crossing *i.e.*, N.T.C. given, heel divergence d = 11 cm. (GATE 2008)

Solution: Given,

$N = 8$

$G = 1.676$ m

$d = 11$ cm $= 0.11$ m

Curve lead (CL) = 2 GN

$= 2 \times 1.67 \times 8 = 26.816$ m

Radius $R = R_0 - \dfrac{G}{2}$

$$R_0 = 2\,GN^2 + 1.5\,G$$

$$= 2 \times 1.676 \times 8^2 + 1.5 \times 1.676$$

$$= 214.528 + 2.514$$

$$= 217.042 \text{ m}$$

$$R = 217.042 - \frac{1.676}{2}$$

$$= 217.042 - 0.838$$

$$= 216.204 \text{ m}$$

Switch lead (SL) $= \sqrt{2\,R_0\,d}$

$$= \sqrt{2 \times 217.042 \times 0.11} = 6.91 \text{ m}$$

Lead $L = CL - SL$

$= 26.816 - 6.91 = 19.906$ m **Ans.**

(**Note:** The overall length of the curve is 26.81 m and radius of the outer curve is 217.042 m

Also tangent point is known. The curve can now be easily set with perpendicular offset from the tangent point).

EXAMPLE 7. Calculate the elements of a turn out for a data given below:

$G = 1.67$ m, $N = 12$, $d = 0.133$ m

angle of switch i.e., $\beta = 1^0\ 8^1$

Solution: When

$N = 12$

$\alpha = 4°\ 45'\ 49''$

Crossing lead $(L) = (G - d)\ \cot\dfrac{\alpha + \beta}{2}$

$$= (1.676 - 0.133)\cot\frac{5°\ 53'\ 49''}{2}$$

$$= 29.950 \text{ m}$$

Radius, $R_0 = \dfrac{G - D}{\cos\beta - \cos\alpha}$

$$= \frac{1.676 - 0.133}{0.99980 - 0.99655} = 475 \text{ m}$$

$$R = R_0 - \frac{G}{2}$$

$$= 475 - \frac{1.676}{2} = 474.162 \text{ m Ans.}$$

EXAMPLE 8. A cross over occurs between two parall B.G. tracks of same crossing number of 1 in $8\frac{1}{2}$ wi straight intermediate portion between the reverse curv Distance between centres of tracks is 5 m. Find the overa length of cross-over. (IES 200

Solution: When,

$N = 8.5$

$G = 1.676$ m

$D = 5$ m

The intermediate straight distance is given by

$$S = (D - G)\,N - G\sqrt{1 + N^2}$$

$$= (5 - 1.676) \times 8.5 - 1.676\sqrt{1 + 8.5^2}$$

$$= 28.25 - 14.34 = 13.91 \text{ m}$$

Overall length of cross-over $l = 4\,GN + S$

$$= 4 \times 1.676 \times 8.5 + 13.91$$

$$= 56.98 + 13.91 = 70.894 \text{ m}$$

Ans. Toal length of crossover is 70.89 metr

EXAMPLE 9. Design a diamond crossing between t BG tracks crossing each at an angle of 1 in 10. (IES 200

Solution: When

$N = 10$

$G = 1.676$

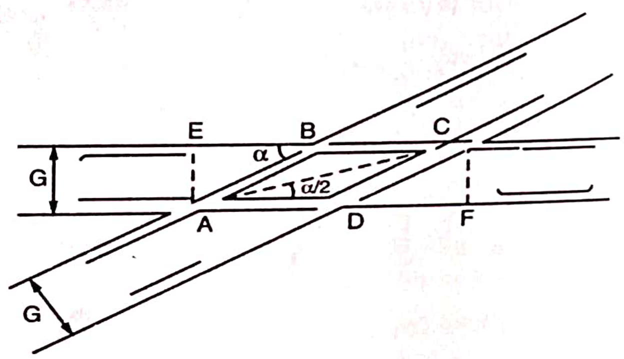


Fig. 13.6.

As per right angle method, $N = \cot\alpha$

$$\alpha = \cot^{-1}(N) = \cot^{-1}(10)$$

$$= 5.7106°$$

$EB = DF = G \cot \alpha$

$= 1.676 \times 10 = 16.76$ m

$BC = G \operatorname{cosec} \alpha$

$= 1.676 \operatorname{cosec} 5.7106°$

$= 16.84$ m

$AB = BC = CD = AD = 16.84$ m

$$AC = G \operatorname{cosec} \frac{\alpha}{2}$$

$$= 1.676 \operatorname{cosec} \left(\frac{5.7106}{2}\right)^\circ = 33.65 \text{ m}$$

$$BD = 2\,BC \sin\left(\frac{5.7106}{2}\right)^\circ$$

$$= 2 \times 16.84 \times \sin\left(\frac{5.7106}{2}\right)^\circ = 1.67 \text{ m}$$

Ans.

EXAMPLE 10. Find the gradient for a broad gauge track such that the grade resistance together with curve resistance due to curve of 2° shall be equal to the resistance due to a ruling gradient of 1 in 200.

(Civil Services Main Exam. 2008)

Solution: As per IS recommendations, grade compensation of B.G. is 0.04% per degree of curve.

Curve resistance for 2° = 0.04 × 2 = 0.08%

$$\text{Ruling gradient} = \frac{1}{200} \times 100 = 0.5\%$$

Gradient for broad gauge track to be provided

= 0.5 – 0.08 = 0.42%

∴ The gradient is 1 in 238

Ans. Required gradient for B.G. track is 1 in 238.

EXAMPLE 11. Calculate the maximum permissible speed on a 1° curve on a Rajdhani route having maximum sanctioned speed of 130 kmph, superelevation provided is 50 mm and the transition length is 60 m. The transition length of the curve cannot be increased due to proximity of a yard. (Civil Services Main Exam. 2009)

Solution: Degree of the given curve = 1°

$$\therefore \text{ Radius of the curve, } R = \frac{1750}{1} = 1750 \text{ m}$$

(*a*) Safe speed on the curve for high speed

$$V = 4.58\sqrt{R}$$

$$= 4.58\sqrt{1750} = 191.60 \text{ say } 192 \text{ kmph}$$

(*b*) Safe speed based on superelevation

Actual superelevation = 5 cm

Maximum cant deficiency for high speed track = 10 cm

∴ Theoretical super elevation = 5 + 10 = 15 cm

Equilibrium speed for the theoretical super elevation

$$15 = \frac{GV^2}{1.27\,R} = \frac{1.676 \times V^2}{1.27 \times 1750}$$

$$V = \sqrt{\frac{15 \times 1.27 \times 1750}{1.676}} = 141.00 \text{ kmph}$$

(*c*) Safe speed based on length of transition curve

$$(i)\ L = \frac{e \times V_{max}}{198}$$

where,

$e = 5$ cm or 50 mm,

$L = 60$ m

$$\therefore \quad V_{max} = \frac{60 \times 198}{50} = 237.6 \text{ kmph}$$

$$(ii)\ L = \frac{D \times V_{max}}{198}$$

where,

$D = 100$ mm

$L = 60$ m

or
$$60 = \frac{100 \times V_{max}}{198}$$

$$\therefore \quad V_{max} = \frac{60 \times 198}{100} = 118.8$$

say 120 kmph

The maximum permissible speed on the given curve is minimum of the following:

(*a*) Safe speed based on high speed = 192 kmph

(*b*) Safe speed from superelevation = 141 kmph

(*c*) Safe speed from length of transition curve = 120 kmph

The safe permissible speed is 120 kmph **Ans.**

EXAMPLE 12. Determine the maximum permissible train load that can be pulled by a locomotive having four parts of driving wheels carrying an axle of 24 tonnes each. The train has no run at a speed of 80 kmph on a straight level B.G. track. Also determine the reduction in speed if the train has to climb a gradient of 1 in 200. (IES 2006)

Solution: Assuming that hauling capacity of the locomotive is equal to 1/6th the load on driving wheels.

Hauling capacity of the locomotive

$$= \frac{1}{6} \times 4 \times 24 = 16 \text{ tonnes}$$

Train resistance on straight level B.G.

$= 0.016\,W + 0.00008\,WV + 0.0000006\,WV^2$

Equating (*a*) and (*b*), we get

$16 = 0.016\,W + 0.00008\,WV + 0.0000006\,WV^2$

Putting $V = 80$ kmph in above equation we get

$16 = 0.0016\,W + 0.0064\,W + 0.00384\,W$

$$W = \frac{16}{0.01184} = 1351.4 \text{ tonnes}$$

say $W = 1350$ tonnes

Total train resistance on straight B.G. track with a gradient of 1 in 200

$$= 0.01\,W + 0.00008\,WV + 0.000000\,6\,WV^2 + W\,\frac{1}{200}$$

Putting value of W as 1350 tonnes in above equation it to equation (a) we get

$$16 = 0.0016 \times 1350 + 0.00008 \times 1350 \times V + 0.0000006 \times 1350 \times V^2 + \frac{1350}{200}$$

$$= 0.00081\ V^2 + 0.108\ V = 7.09$$

or $V = 50$ kmph

Reduction in speed = 80 – 50 = 30 kmph **Ans.**

EXAMPLE 13. A train having 20 wagons weighing 18 tonnes each is to run at a speed of 50 kmph. The tractive effort of a 2-8-2 locomotive with 22.5 tonnes load on each driving axle is 15 tonnes. The weight of locomotive is 120 tonnes. Rolling resistance of wagons and locomotive are 2.5 kg/tonne and 3.5 kg/tonne respectively. The resistance which depend upon the speed are computed as 2.65 tonnes. Find out the steepest gradient for these conditions.

(IES 2009)

Solution: Total weight of train = weight of locomotive + weight of wagons

= 120 + 18 × 20 = 480 tonnes

Rolling resistance of each wagon = 2.5 × 18 = 45 kg

Rolling resistance of all wagons = 45 × 20 = 900 kg
= 0.9 tonnes

Rolling resistance of locomotive = 120 × 3.5 = 420 kg
= 0.42 tonnes

Total rolling resistance of locomotive and wagon
= 0.9 + 0.42 = 1.32 tonnes

Resistance depending upon speed = 2.65 tonnes

Atmospheric resistance = $0.0000006\ WV^2$
$= 0.000006 \times 480 \times 50^2 = 0.72$ tonnes

Train resistance on straight track = Rolling resistance + Resistance due to speed + Atmospheric resistance + Resistance due to gradient.

$$= 1.32 + 2.65 + 0.72 + \frac{480}{\text{gradient}}$$

$$= 4.69 + \frac{480}{\text{gradient}}$$

Tractive effort of locomotive = 15 tonnes

Equating train resistance to tractive effort, we get,

$$4.69 + \frac{480}{\text{gradient}} = 15$$

gradient = 46.55

Ans. Steepest gradient is 1 in 46.55

EXAMPLE 14. On a broad gauge rail line for a 3 degree curve the equilibrium cant is provided for a speed of 80 kmph. Calculate the value of equilibrium cant. Allowing a maximum cant deficiency, what would be the permissible speed on the track? **(IES 2010)**

Solution: Degree of given curve = 3°

$$\text{Radius of the curve} = \frac{1750}{3}\text{m} = 583.3 \text{ m}$$

Equilibrium cant is given by

$$e = \frac{GV^2}{1.27\,R}$$

$$= \frac{1.676 \times 80 \times 80}{1.27 \times 583.3} = 14.48 \text{ cm}$$

$$= 1.315 \times \frac{80 \times 80 \times 3}{1750} = 14.42 \text{ cm}$$

Theoretical cant = Equilibrium cant + cant deficiency
= 14.48 + 7.60 = 22.08 cm

Again $$e = \frac{GV^2}{1.27\,R}$$

$$\therefore \quad V = \sqrt{\frac{1.27 \times e \times R}{G}}$$

$$= \sqrt{\frac{1.27 \times 22.08 \times 583.3}{1.676}} = 98.79 \text{ kmph}$$

According to railway boards speed formula

$$V = 4.35\sqrt{R - 67}$$

$$= 4.35\sqrt{583.3 - 67}$$

$$= 4.35 \times 22.072 = 98.83 \text{ kmph}$$

$$= 98 \text{ kmph}$$

Hence, maximum permissible speed *i.e.*, lower of the values = 98 kmph. **Ans.**

EXAMPLE 15. If a 8° curve diverges from a main curve of 5° in an opposite direction in the layout of a BG yard, calculate the superelevation and the speed on the branch line, if the maximum speed permitted on the main line is 50 kmph. **(GATE 20**

Solution: Equilibrium cant required for 45 kmph speed be found from following equation:

$$e = \frac{GV^2}{1.27\,R}$$

where,

$G = 1.676$ m for B.G.

$V = 50$ kmph

$$R = \frac{1750}{5°}$$

$$\therefore \quad e = \frac{1.676 \times 50 \times 50}{1.27} \times \frac{5}{1750}$$

$$= \frac{20950}{2184.40} = 9.426 \text{ cm}$$

For board gauge, the cant deficiency permitted for main line is 7.6 cm

so the cant for main track = 9.426 – 7.6 = 1.83 cm

Therefore the cant to be provided for branch track
= – 1.83 cm

It is a negative cant of 1.83

With cant deficiency of 7.6 cm which is permissible, speed of the train will be for a cant of

$7.6 + (-1.83 \text{ cm}) = 5.77$ cm

Permissible speed on branch line can be worked out from formula given earlier.

$$5.77 = \frac{1.676 \times V^2}{1.27} \times \frac{8°}{1750}$$

[Degree of branch line = 8°]

$$V^2 = \frac{5.77 \times 1.27 \times 1750}{8 \times 1.676}$$

$$V^2 = 956.43$$

∴ $V = 30.93$ kmph **Ans.**

EXAMPLE 16. Given the following:

Degree of curve = 1°

Superelevation = 80 mm

Length of transition curve = 120 mm

Maximum speed of the section likely to be sanctioned = 160 kmph. For a B.G. route, calculate the following:

(i) Safe speed on the curve

(ii) Speed calculated from the consideration of the superelevation, and

(iii) Speed calculated from the consideration of the length of transitions

Assume max cant deficiency for high speed route to be 100 mm and broad gauge = 1676 m

(Civil Service Main Exam 2010)

Solution: Based on I.R.S. radius of the curve

$$R = \frac{1750}{\text{Degree}} = \frac{1750}{1} = 1750 \text{ m}$$

Safe speed on the curve

$$V = 4.58\sqrt{R} = 4.58\sqrt{1750}$$

$$= 191.60 \text{ kmph}$$

Speed from considerations of superelevation

Equilibrium cant = Actual cant + cant deficiency

$$= 8.0 + 10.0 = 18 \text{ cm}$$

Now, $$V^2 = \frac{e \times 1.27 \times R}{G} = \frac{18 \times 1.27 \times 1750}{1.676}$$

∴ $V = 154.50$ kmph

Speed based on the length of transition curve

(a) $$L = \frac{e \times V_{max}}{198}$$

Here $e = 80$ mm; $L = 120$ m

∴ $$120 = \frac{80 \times V_{max}}{198}$$

or $$V_{max} = \frac{120 \times 198}{80} = 297 \text{ kmph}$$

(b) $$V_{max} = \frac{198 \times L}{D}$$

Here, $L = 120$ m; $D = 100$ mm

∴ $$V_{max} = \frac{198 \times 120}{100} = 237.6 \text{ kmph } \textbf{Ans.}$$

EXAMPLE 17. Calculate the superelevation to be provided for a $1\frac{1°}{2}$ transitioned curve on a high speed route. The maximum sanctioned speed in the section is 120 kmph. The speed for calculating the super-elevation is set at 88 kmph; and the booked speed of goods trains in 50 kmph. What is the length of transition to be provided.

(Civil Services main Exam. 2012)

Solution: Superelevation:

$$\text{Radius of the curve} = \frac{1750}{1.5} = 1166.67 \text{ m}$$

The superelevation for B.G. high speed route is given by the expression

$$e = 1.315\frac{V^2}{R}, \text{ where } V \text{ is in kmph}$$

$$= \frac{1.315 \times 88^2}{1166.67} = 8.73 \text{ cm}$$

∴ Superelevation, $e = 8.73$ cm

Length of the transition curve:

(i) Based on an arbitrary gradient

$$L = 7.20\ e$$

where e is actual superelevation in cm.

$$= 7.20 \times 8.73 = 62.86 \text{ m}$$

(ii) Based on the rate of change of cant deficiency

$$L = 0.073\ D \times V_{max}$$

where D is cant deficiency in cm for maximum speed

$$= 0.073 \times 7.6 \times 120 = 66.58 \text{ m}$$

(iii) Based on the rate of change of superelevation

$$L = 0.073e \times V_{max}$$

$$= 0.073\ e \times V_{max}$$

$$= 0.073 \times 8.73 \times 120 = 76.48 \text{ m}$$

The greatest value of equations (i), (ii) and (iii) is adopted as the length of the transition curve *i.e.*, 77 m. Hence, it is 77 m. **Ans.**

4. The completed railway line on which regular traffic of trains has started is called
(*a*) Railways (*b*) Permanent way
(*c*) Steel way (*d*) Rails

5. Majority of permanent way length is under
(*a*) Metre gauge (*b*) Narrow gauge
(*c*) Broad gauge (*d*) Standard gauge

6. In broad gauge, the clear horizontal distance between the inner faces of two parallel rails forming the track is
(*a*) 1 m (*b*) 0.792 m
(*c*) 0.6096 (*d*) 1.676 m

7. For connecting main cities and for routes of importance the type of gauge adopted is
(*a*) Meter gauge (*b*) Broad gauge
(*c*) Narrow gauge (*d*) Mono rail

8. The choice of gauge depends upon
(*a*) Volume and nature of traffic
(*b*) Speed of train
(*c*) Physical features of the country
(*d*) All the above

9. Generally the rail sections used in India are
(*a*) Double loaded (*b*) Bull headed
(*c*) Flat footed
(*d*) All the above are correct

10. The bottom width of foot in a flat footed rail is
(*a*) 66.7 mm (*b*) 70 mm
(*c*) 78.6 mm (*d*) 136.5 mm

11. Rail section first designed on Indian railways was
(*a*) Bull headed (*b*) Double headed
(*c*) Flat footed (*d*) None of the above

12. The standard length of rail for broad gauge and metre gauge respectively are
(*a*) 12 m and 12 m (*b*) 13 m and 12 m
(*c*) 13 m and 13 m (*d*) 12 m and 13 m

13. The rail is designed by its
(*a*) Weight (*b*) Length
(*c*) Weight/unit length (*d*) Cross-section

14. The steel used for rail contains two important
(*a*) Carbon and silicon
(*b*) Sulphur and silicon
(*c*) Carbon and managanese
(*d*) Manganese and phosphorus

15. The rails are made of
(*a*) Cast iron (*b*) Mild steel
(*c*) High carbon steel (*d*) High speed steel

16. Weight of rail used for metre gauge is
(*a*) 24.8 to 29.8 kg (*b*) 30 to 33 kg
(*c*) 44.7 kg (*d*) 52 kg

17. 52 kg rails are mostly used in
(*a*) Narrow gauge (*b*) Broad gauge
(*c*) Metre gauge (*d*) None of the above

18. The cross sectional area of a 52 kg flat footed rail is
(*a*) 61.55 cm^2 (*b*) 66.15 cm^2
(*c*) 72.35 cm^2 (*d*) None of the above

19. Head width of 52 kg rail section is
(*a*) 61.9 mm (*b*) 66.7 mm
(*c*) 67 mm (*d*) 72.33 mm

20. In India, the ratio between the weight of the rail and the locomotive axle load is
(*a*) 310 (*b*) 410 (*c*) 510 (*d*) 610

21. The maximum axle load in tones in India for broad gauge is
(*a*) 13.26 (*b*) 17.34
(*c*) 21.36 (*d*) 28.56

22. Height of the rail for 52 kg section rail is
(*a*) 129 mm (*b*) 143 mm
(*c*) 156 mm (*d*) 172 mm

23. On Indian Railways, the standard length of rails for broad gauge track is
(*a*) 10.06 m (*b*) 10.97 m
(*c*) 11.98 (*d*) 12.8 m

24. On Indian Railways, the standard length of rails for metre gauge track is
(*a*) 10.06 m (*b*) 10.97 m
(*c*) 11.98 m (*d*) 12.8 m

25. The main advantage of long rail over short rail is
(*a*) It requires less number of rail fastenings
(*b*) It provides smooth running of trains
(*c*) Low maintenance cost
(*d*) All of the above

26. Top of rails of a track are placed at an inward slope of
(*a*) 1 in 10 (*b*) 1 in 15
(*c*) 1 in 20 (*d*) 1 in 30

27. The tread of wheels is provided on outward slope of
(*a*) 1 in 10 (*b*) 1 in 15
(*c*) 1 in 20 (*d*) 1 in 25

28. The section of rail is decided on the basis of
(*a*) Type of rails (*b*) Spacing of the sleepers
(*c*) Gauge of the track (*d*) Speed of trains

29. Maximum wheel base distance provided on Indian B.G. tracks is
(*a*) 4.096 m (*b*) 6.096 m
(*c*) 7.096 m (*d*) 9.096 m

30. Bending of rails to connect curvature is done if the curve is
(*a*) less than 3 (*b*) more than
(*c*) less than 4 (*d*) more than 4

31. The dynamic effect of wheel loads is caused due to
(*a*) Dead weight of wheels
(*b*) Dead weight of engine
(*c*) Speed and hammer blows
(*d*) Track deformation

32. Maximum degree of curvature for metre gauge is limited to
(a) 10° (b) 16°
(c) 30° (d) 40°

33. The filter in a rail section is provide to
(a) Increase the vertical stiffness
(b) Increase the lateral strength
(c) Reduce the wear
(d) Avoid the stress concentration

34. The compulsory test conducted for rails is
(a) Hammer test (b) Falling weight test
(c) Tensile test (d) Both (a) and (b) above

35. The check rails are provided on a broad gauge track on the inner side of inner rails if the sharpness of the curve is more than
(a) 4° (b) 6°
(c) 8° (d) 10°

36. On sharp curves the distance between the inner rail and check rail is
(a) 33 mm (b) 44 mm
(c) 48 mm (d) 55 mm

37. Bull headed rails are generally provided at
(a) Curved tracks (b) Points and crossings
(c) Bifurcation of tracks (d) Bridges

38. A rail which is tapered to a toe at one end and has a heel at the other end is called as
(a) Stock rail (b) Tongue rail
(c) Wing rail (d) Lead rail **(IES 2011)**

39. Coning of wheels is provided
(a) To check lateral movement of wheels
(b) To avoid damage to inner faces of wheels
(c) To avoid discomfort to passengers
(d) All the above **(GATE 2011)**

40. The rails go out of their original positions due to insufficient expansion gap. This is known as
(a) Hoggin (b) Creeping
(c) Buckling (d) None of the above

41. Creep is the
(a) Longitudinal movement of rail
(b) Lateral movement of rail
(c) vertical movement of rail
(d) None of the above **(GATE 2012)**

42. Creep is greater
(a) On curves
(b) In new rail than in old rails
(c) Both (a) and (b) above
(d) None of the above **(IES 2012)**

43. Anticreep bearing plates are provided on
(a) Bridges (b) Joints
(c) Both sides of sleepers
(d) All of the above

44. Creep does not
(a) Vary at uniform rate
(b) Continue in one direction
(c) Occur in both the rails by equal amount
(d) All of the above

45. Creep of rails is measured by
(a) Creep indicator (b) Fishing string
(c) Anchors (d) None of the above

46. Creep causes
(a) Buckling of track
(b) Movement of sleepers out of position
(c) Points and crossings get distorted
(d) All of the above

47. Creep anchors are usually not provided at
(a) Bridges
(b) Level crossings
(c) Points and crossings
(d) None of the above **(GATE 2008)**

48. Usually adjustment of rails is needed when creep exceeds
(a) 10 mm (b) 50 mm
(c) 150 mm (d) 100 mm

49. Anti-creep anchors are fixed to rails by
(a) Wedging (b) Spring grip
(c) Clamping (d) All of the above

50. Wear on top or head of rail occurs due to
(a) Heavy axle load
(b) abrasion of rolling wheels
(c) Constant break application
(d) All of the above **(GATE 2009)**

51. The rails get damaged due to
(a) Wear
(b) Bending
(c) Excessive hogging defect
(d) All of the above

52. The causes of formation of kinks in a rail is
(a) Loose packing at joints
(b) Defect in cross level at joints
(c) Defect in gauge and alignment
(d) All of the above

53. The misalignment of rails due to temperature changes is known as
(a) Hogging (b) Creeping
(c) Buckling (d) Bulging

54. When the rail end rests on a joint sleeper, the joint is termed as
(a) Supported joint (b) Suspended joint
(c) Base joint (d) Welded joint
(IES 2007)

55. When two different rail sections are joined together by means of fish plates, the joint is known as
(a) Supported joint (b) Suspended joint
(c) Compromise joint (d) Staggered joint

56. Staggered joints are generally provided
(a) On curves
(b) On straight tracks
(c) To join two rail sections
(d) None of the above (IES 2007)

57. A welded rail joint is generally
(a) Supported on a sleeper
(b) Supported on a metal plate
(c) Left suspended
(d) Supported on ballast

58. Perfect and strongest type of joints is a
(a) Welded joint (b) Staggered joint
(c) Supported joint (d) Suspended joint

59. Rails are welded by
(a) Gas welding (b) Arc welding
(c) TIG welding (d) Thermit welding

60. The Indian practice is to weld maximum of
(a) Two rail lengths (b) Three rail lengths
(c) Four rail lengths (d) Five rail lengths

61. Generally the shape of fish plate is
(a) Rectangular (b) Circular
(c) Bone shaped (d) Eliptical

62. Bone shaped section of fish plate is commonly used for connecting
(a) Flat footed rails (b) Bull headed rails
(c) Double headed rails (d) All the above are correct

63. The thickness of fish plate generally used in Indian Railway is
(a) 10 m (b) 16 mm
(c) 20 mm (d) 25 mm

64. The main function of a fish plate is
(a) To join the two rails together
(b) To join rails with sleeper
(c) To allow rail to expand and contract freely
(d) All of the above

65. The most commonly used type of metal key is
(a) Stuart's key
(b) Spring coiled key
(c) Morgan key
(d) All the above are correct

66. Number of fish bolts per fish plate is
(a) 2 (b) 4
(c) 6 (d) 8

67. The main function of sleepers is
(a) To support rails
(b) To hold rails at correct gauge
(c) To distribute load from rails to ballast
(d) All of the above

68. The type of sleeper used depends on
(a) Easy fixing and removal of rails
(b) Provisions for sufficient bearing area for rail
(c) Initial and maintenance cost
(d) All of the above

69. Ideal sleepers are
(a) R.C.C. sleepers (b) Steel sleepers
(c) Cast iron sleepers (d) Wooden sleepers

70. Best wood for wooden sleepers is
(a) Chir (b) Sal
(c) Teak (d) Shesham

71. Sleepers preferred on joints are
(a) Wooden sleepers (b) Concrete sleepers
(c) Steel sleepers (d) CST-9 sleepers

72. Standard size of wooden sleeper for BG track is
(a) 274 × 25 × 13 cm
(b) 183 × 20 × 11 cm
(c) 152 × 15 × 10 cm
(d) 250 × 26 × 12 cm

73. In India, generally sleeper density of sleepers per rail length used is
(a) 12 (b) 18
(c) 24 (d) 30

74. Standard size of wooden sleepers for M.G. track is
(a) 274 × 25 × 13 cm (b) 183 × 20 × 11 cm
(c) 152 × 15 × 10 cm (d) 250 × 26 × 12 cm

75. The minimum length of wooden sleepers used on B.G. line is
(a) 2 m (b) 2.2 m
(c) 2.4 m (d) 2.6 m

76. Generally the life of wooden sleepers is taken as
(a) 2 to 3 years (b) 5 to 8 years
(c) 12 to 15 years (d) 35 to 50 years

77. Sleeper density of a particular type depends on
(a) Axle load and speed
(b) Type of section of the rails
(c) Type of ballast and ballast cushion
(d) All of the above

78. The sleepers providing the best rigidity of track is
(a) Wooden (b) R.C.C.
(c) Cast iron (d) All of the above

79. The sleeper providing best elasticity is
(a) Wooden (b) R.C.C.
(c) Steel (d) Cast iron

80. Spacing of sleepers is kept
(a) Same throughout the length of rail
(b) Closer near the joints
(c) Closer at the middle of rails
(d) None of the above

81. Composite sleeper index is the index of
(a) Strength and hardness
(b) Strength and toughness
(c) Hardness and wear resistance
(d) Toughness and wear resistance

82. Minimum composite index for wooden sleepers used on Indian railways is
(a) 783 (b) 1252
(c) 1352 (d) 1452

83. Minimum composite sleeper index for wooden sleepers used over bridge is
(a) 783 (b) 1252
(c) 1352 (d) 1452

84. Loose jaws of steel through sleepers are made of
(a) Cast steel (b) Cast iron
(c) Spring steel (d) Mild steel

85. The formation width for a railway track depends as
(a) Type of gauge
(b) Number of tracks to be laid side by side
(c) Both (a) and (b) above
(d) None of the above

86. The formation width for a single line meter gauge track in embankment is
(a) 3.70 m (b) 4.88 m
(c) 6.1 m (d) 5.49 m

87. The formation width for a double line B.G. in embankment is
(a) 7.32 m (b) 8.53 m
(c) 10.67 m (d) 10.06 m

88. The formation width for double line B.G. track in cutting excluding side drains, taken as
(a) 7.901 m (b) 7.93 m
(c) 10.06 m (d) 10.83 m

89. The side slope of embankment for a railway track is taken as
(a) 1 : 1 (b) 1.5 : 1
(c) 2 : 1 (d) 2.5 : 1

90. The minimum spacing in between two adjoining railway tracks in B.G. in station limits should be
(a) 4.27 m (b) 4.73 m
(c) 3.35 m (d) 1.676 m

91. Dog spikes are used for fixing rail to the
(a) Wooden sleepers (b) Concrete sleepers
(c) CST-9 sleepers (d) Steel sleepers

92. Overall depth of a dog spike is
(a) 120.6 mm (b) 135 mm
(c) 155.90 mm (d) None of the above

93. The spike used for fixing chairs of bull headed rail to wooden sleepers is
(a) Dog spike (b) Round spike
(c) Elastic spike (d) Rail spike

94. The sleepers resting directly on girder are fastened to the top plane of girder by
(a) Dog bolts (b) Fish bolts
(c) Fang bolts (d) None of the above

95. The bearing plate used in all joints and on curves to give better bearing area to the rails is
(a) Mild steel coasted bearing plate
(b) Mild steel flat bearing plate
(c) Cast iron anticrep
(d) All of the above

96. Flat mild steel bearing plates are used
(a) On joints and curves
(b) At location where creep is likely to occur
(c) For points and crossing in the lead portion
(d) None of the above

97. The best suited material for the ballast is
(a) Broken stone (b) Gravel or river pebbles
(c) Ashes or cinders (d) Brick ballast

98. The nominal size of the ballast used for points and crossings is
(a) 10 mm (b) 25 mm
(c) 40 mm (d) 50 mm

99. The width of ballast across a B.G. is
(a) 1.83 m (b) 2.00 m
(c) 2.25 m (d) 3.35 m

100. The depth of ballast for a B.G. line is
(a) 15 – 20 cm (b) 20 – 25 cm
(c) 25 – 30 cm (d) 35 – 40 cm

101. The size of ballast for wooden sleeper track is
(a) 2.54 cm (b) 3.80 cm
(c) 5.1 cm (d) 6.0 cm

102. Minimum depth of ballast cushion for a B.G. wooden sleeper of size 274 × 25 × 13 cm with 65 cm sleeper spacing is
(a) 15 cm (b) 20 cm
(c) 25 cm (d) 30 cm

103. Then quantity of ballast required per meter length of a B.G. track is
(a) 1.036 m^3 (b) 0.071 m^3
(c) 0.053 m^3 (d) 0.41 m^3 **(GATE 2012)**

104. Sand is used as ballast in case of
(a) Wooden sleepers (b) Concrete sleepers
(c) Cast iron sleepers (d) Steel sleepers

105. The gradient which determine the maximum load that the engine can haul on the section is known as
(a) Ruling gradient (b) Momentum gradient
(c) Helper gradient (d) Gradient in station yard
(GATE 2012)

106. The gradient generally adopted in India in plains is
(a) 1 in 100 to 1 in 150 (b) 1 in 150 to 1 in 200
(c) 1 in 200 to 1 in 250 (d) 1 in 500

107. Minimum gradient in station yards is limited to
(a) Zero (b) 1 in 500
(c) 1 in 750 (d) 1 in 1000

108. The shape of transition curve used by Indian railway is
(a) Spiral (b) Sine curve
(c) Cubic parabola (d) Lemniscate

109. Degree of railway curve is defined as number of degrees subtended at the center of a curve by an arc of
(a) 15.5 m (b) 20.0 m
(c) 30.5 m (d) 35 m
(IES 2012)

110. Safe speed on a curve of radius 970 m provided with two transition curves on B.G. track is
(*a*) 120 km/hr (*b*) 132 km/hr
(*c*) 142 km/hr (*d*) 152 km/hr

111. In railway, super elevation is provided to
(*a*) Counteract the centrifugal path
(*b*) Counteract the centripetal pull
(*c*) Facilitate drainage
(*d*) Have all the effects mentioned above

112. The limiting value of super elevation for B.G. track in Indian Railways is
(*a*) 10 cm (*b*) 15 cm
(*c*) 16.50 cm (*d*) 30 cm

113. According to the railway board, the limiting value of cant is
(*a*) $\frac{G}{5}$ (*b*) $\frac{G}{10}$
(*c*) $\frac{G}{15}$ (*d*) None of the above
where *G* is the gauge. **(GATE 2008)**

114. Normally maximum cant permissible on M.G. is
(*a*) 60 mm (*b*) 75 mm
(*c*) 90 mm (*d*) 140 mm

115. The limiting value of cant gradient for all gauges is
(*a*) 1 in 250 (*b*) 1 in 360
(*c*) 1 in 729 (*d*) 1 in 1000

116. One degree of curve is equal to
(*a*) 1700/R (*b*) 1720/R
(*c*) 1750/R (*d*) None of the above
where R is the radius of curve.

117. If the ruling gradient is 1 in 150 on a particular section of a broad gauge track, the allowable ruling gradient on a 4° curve in the track will be
(*a*) 0.51% (*b*) 0.53%
(*c*) 0.61% (*d*) 0.67% **(IES 2011)**

118. Arrangement made to divert the train from one track to another is known as
(*a*) Railway crossing (*b*) Railway junction
(*c*) Turn out (*d*) None of the above
(IES 2011)

119. The railway track from which a train is to be diverted is called
(*a*) Branch track (*b*) Main or through track
(*c*) Points and crossings (*d*) All the above are correct

120. The fixed rail in a railway track against which the tongue rail fits is known as
(*a*) Stock rail (*b*) Lead rail
(*c*) Wing rail (*d*) Point rail
(GATE 2006)

121. The movable tapered end of the tongue rail is known as
(*a*) Throw of switch (*b*) Stretcher bar
(*c*) Heel of switch (*d*) Toe of switch

122. The bent-up lengths of rail used in front of nose of crossing which help in channelising the train wheels in their proper routes are known as
(*a*) Point rail (*b*) Lead rail
(*c*) Splice rail (*d*) Wing rail

123. The arrangement made when left hand rail of one track crosses right hand rail of another track is called
(*a*) Acute angle crossing (*b*) Diamond crossing
(*c*) Square crossing (*d*) Obtuse angle crossing

124. The arrangement consisting of three tracks used for changing the direction of engine is called
(*a*) Three throw switch (*b*) Triangle
(*c*) Three ladder track (*d*) Turn table

125. A triangle used for turning the face of locomotives consists of
(*a*) Three turnouts (*b*) Three splits
(*c*) One turnout and two splits
(*d*) Two turnouts and one split

126. The plate laying is usually done in India by
(*a*) Side method
(*b*) American method
(*c*) Telescope method
(*d*) All the above are correct

127. The point from where the laying of a new railway track starts is known as
(*a*) Rail-head (*b*) Base
(*c*) Material depot (*d*) Station

128. The horizontal distance from the material depot to the rail head is called
(*a*) Lead (*b*) Lift
(*c*) Rail-head (*d*) Site distance

129. The point upto which the new railway track laid at any time is called
(*a*) Rail head (*b*) Base
(*c*) Terminal (*d*) Station

130. While preparing sub-grade of a railway line the grubbing operation means
(*a*) Compaction and consolidation of earth work
(*b*) Removal and disposal of stumps and roots of trees
(*c*) Checking of sub-grade
(*d*) Filling of cutting of earth work in railway sub-grade

131. The minimum height of embankment above the highest flood mark in the area should be
(*a*) 30 cm (*b*) 60 cm
(*c*) zero cm (*d*) 100 cm

132. The additional track connected to main line at both of its ends is called
(*a*) Loop line (*b*) Running line
(*c*) Main line (*d*) None are correct

133. The railway station of which a track lines meets a main line is called
(*a*) Way side station (*b*) Junction station
(*c*) Terminal station (*d*) Flag station

134. The yard where trains and other loads are received, sorted out, trains formed and dispatched onwards are known as
(*a*) Station yard (*b*) Marshalling yard
(*c*) Locomotive yard (*d*) Goods yard
(GATE 2012)

135. The minimum length of a passenger platform for broad gauge railway should not be less than
(*a*) 183 metres (*b*) 250 metres
(*c*) 305 metres (*d*) 495 metres

136. The height of the platform above the rail surface for broad gauge track should be
(*a*) 22.9 cm to 40.6 cm (*b*) 30.5 cm to 40.6 cm
(*c*) 76.2 cm to 83.8 cm (*d*) 83.8 cm to 98.2 cm

137. Device for interlocking is
(*a*) Detector (*b*) Treadle bar
(*c*) Point lock (*d*) All the above

138. Disc signals are provided for
(*a*) Passenger trains (*b*) Goods trains
(*c*) Marshalling operations
(*d*) Shunting operations

139. The latest system of signalling introduced is
(*a*) Automatic block system
(*b*) Section clear system
(*c*) Pilot guard system
(*d*) C.T.C. system
(IES 2012)

140. Accidents can be avoided by adopting
(*a*) C.T.C. system (*b*) A.T.C. system
(*c*) Interlocking (*d*) Pilot guard system

141. The length of track under the control of a Ganger is
(*a*) 1 to 2 km (*b*) 3 to 5 km
(*c*) 5 to 6 km (*d*) 10 to 15 km

142. The technical officer of the rank of Section Officer in the maintenance organization of Indian Railways is called
(*a*) Gangmate
(*b*) Assistant Permanent Way Inspector
(*c*) Permanent Way Inspector
(*d*) None of these are correct

143. The head of a gang in maintenance organization of railways is called
(*a*) A.P.W.I (*b*) Ganger
(*c*) P.W.I. (*d*) Keyman

144. The sleeper density of a BG track is (n + 6) in metric units. The number of sleepers per 1.024 km length of track is
(*a*) 1520 (*b*) 1630
(*c*) 1720 (*d*) 1800

145. The axle load including weight of wheels and axle (provided the rail has not lost more than 5% of its original section) for a 44.6 kg/m rail section for broad gauge shall be
(*a*) 17.5 tonnes (*b*) 19.0 tonnes
(*c*) 23.0 tonnes (*d*) 28.5 tonnes

146. A train is hauled by 2-8-2 locomotive with 22.5 tonnes load on each driving axle. Assuming the coefficient of rail wheel to be 0.25, what would be the hauling capacity of the locomotive?
(*a*) 15.0 tonnes (*b*) 22.5 tonnes
(*c*) 45.0 tonnes (*d*) 90.0 tonnes
(IES 2008)

147. Consider the following statements:
Automatic signalling system result in
1. Greater risk
2. Higher efficiency
3. Avoidance of block instruments
4. Higher operating cost
Of these statements
(*a*) 1 and 2 are correct (*b*) 3 and 4 and correct
(*c*) 1 and 4 are correct (*d*) 2 and 3 are correct

148. In 'Full face' method of constructing tunnel, the first operation relates to
(*a*) Removal of bottom portion
(*b*) Excavation of one drift in the centre
(*c*) Removal of top portion
(*d*) Excavation being done along the perimeter

149. Consider the following situations
1. Soil is soft
2. Volume of existing surface traffic on the alignment is heavy
3. Track is at a deeper level
4. Water table is high
In the construction of Metro Railways 'cut and cover' method of construction is suitable in situation listed at
(*a*) 1 and 2 (*b*) 1 and 3
(*c*) 1 and 4 (*d*) 2 and 3

150. Which of the following statements regarding ballast materials are correct?
1. Brick ballast has poor drainage characteristics
2. Coal ash not used as ballast with steel or cast iron sleepers
3. Gravel ballast gives better performance in soft formation
4. Sand ballast causes excessive wear on top of rail
Select the correct answer using the codes given below
Codes:
(*a*) 1 and 2 (*b*) 1 and 4
(*c*) 1 and 3 (*d*) 2, 3 and 4

151. Which one of the following relates to the percussion theory for explaining the causes of creep?
(*a*) Pushing the rails forward and backward during starting and slowing
(*b*) Impact of wheels at the rail end ahead at joints
(*c*) Pushing the rail off the track due to the thrust on driving wheels
(*d*) Formation of vertical reverse curves behind and ahead of wheels

152. Wear of rail is maximum in
(*a*) Tangent track (*b*) Sharp curve
(*c*) Tunnels (*d*) Coastal area

153. For taking the consideration of creep of rails, the sleepers that need no anchoring arrangement:
(*a*) Wooden sleeper (*b*) Steel sleeper
(*c*) Cast iron sleeper (*d*) Concrete sleeper

154. Bending of the rails for laying is curvatures is resorted when the degree of curvature exceeds
(*a*) 3°
(*b*) 4°
(*c*) 5°
(*d*) Irrespective of degree of curvature

155. Metal sleepers are superior to wooden sleepers with respect to
(*a*) Cost (*b*) Durability
(*c*) Track circuiting (*d*) Fastening

156. For a 8° curve task diverging from a main curve of 5° in an opposite in the layout of a broad gauge yard, the cant to be provided for the branch track for a maximum speed of 45 kmph on the main line and $G = 1.67$ m is (permitted cant deficiency for main track line = 7.6 cm)
(*a*) 0.168 cm (*b*) – 0.168 cm
(*c*) 7.432 (*d*) 7.768 cm

157. The given figure represents a
(*a*) Good yard (*b*) Gravitational yard
(*c*) Hump yard (*d*) Loco yard

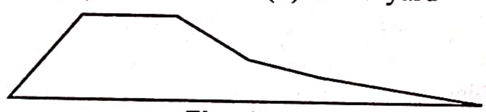


Fig. 13.7.

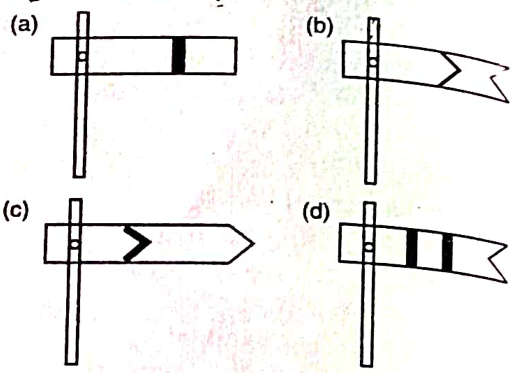
158. On a single rail track, goods trains loaded with heavy iron material run starting from A to B and then empty wagons run from B to A. The amount of creep in the rails
(*a*) Will be more in the direction of *B* to *A*
(*b*) Will be more in the direction of *A* to *B*
(*c*) Will be maximum at the middle of *A* and *B*
(*d*) Can not be determined from the given data

159. For laying a railway track materials required are *A*. Rail *B*. Fishplates, *C*. Fish bolts, *D* bearing plates
The quantities required fore one km of B.G. track will be

	A	B	C	D
(*a*)	154	308	308	154
(*b*)	154	308	616	154
(*c*)	77	154	308	77
(*d*)	168	336	672	168

160. Which one of the following rail failures is caused by loose fish bolts at expansion joints?
(*a*) Crushed head (*b*) Angular break
(*c*) Split head (*d*) Transverse fressure

161. Which one of the following figure represents a '... signal' in Railways?



162. After lining of tunnels the grouting processes is d... to
(*a*) Seal off the water leakage
(*b*) Have proper bond between the lining and the tu...
(*c*) Fill the space left between the lining and the tu...
(*d*) All the above

163. The points fixed between a pair of converging track... indicate possibility of side collision are known as
(*a*) Scotch blocks (*b*) Trap switches
(*c*) Fouling marks (*d*) Buffer stops

164. The grade compensation that can be provided for B.G. track at a 4° curvature will be
(*a*) 0.12% (*b*) 0.16%
(*c*) 0.20% (*d*) 0.24%

165. The curve resistance for a 50 tonnes train on BG track at a 4° curvature will be
(*a*) 0.08 tonne (*b*) 0.06 tonne
(*c*) 0.10 tonne (*d*) 0.05 tonne

166. Drift method of tunneling is used to construct tunnels in
(*a*) Soft-ground (*b*) Rocks
(*c*) Self-supporting grounds
(*d*) Broken grounds **(GATE 2008)**

167. What is the correct sequence of the following events in rock tunnelling?
1. Marking tunnel profile
2. Loading explosive and blasting
3. Checking miss fire
4. Making
5. Removing Foul gas
6. Setting up and drilling
7. Gunniting

Select the correct answer using the codes given below:

Codes:
(*a*) 1, 6, 5, 3, 4, 2, 7 (*b*) 1, 2, 6, 3, 5, 4, 7
(*c*) 1, 6, 2, 5, 4, 3, 7 (*d*) 1, 6, 2, 5, 3, 4, 7
(Civil Service Exam. 2008)

168. Which of the following factors help in ensuring track modulus in a railway track?
(*a*) Gauge and formation width
(*b*) Track materials and sleeper density
(*c*) Degree of curvature and super elevation
(*d*) Length of rail and flange width **(IES 2008)**

169. The track modulus is an index of measure of which of the following?
(*a*) Resistance due to friction
(*b*) Resistance due to shear
(*c*) Resistance due to deformation
(*d*) Resistance due to rolling

170. The vertical wear on tongue rail should not exceed which one of the following?
(*a*) 6 mm (*b*) 10 mm
(*c*) 12 mm (*d*) 15 mm **(IES 2008)**

171. Which of the following are related to maintenance of railway track?
1. Jim crow and gauge bar
2. Through packing and boxing
3. Buffer stop and sand hump
4. Creep adjustment

Select the correct answer using the codes given below:
(*a*) 1, 2 and 3 (*b*) 1, 3 and 4
(*c*) 1, 2 and 4 (*d*) 2, 3 and 4 **(IES 2010)**

172. Which one of the following is not related to theories of creep of rails?
(*a*) Wave theory (*b*) Percussion theory
(*c*) Drag theory (*d*) Reversal theory
(IES 2007)

173. Which one of the following methods of tunnelling is employed if the state is sub-aqueous?
(*a*) Shield tunnelling (*b*) Drift system
(*c*) Liner plate method (*d*) Pilot tunnel method
(IES 2008)

174. Weisbach triangle method may be used for which one of the following?
(*a*) To carry out surface alignment of a tunnels
(*b*) To transfer levels underground for a tunnel
(*c*) To connect surface and underground tunnel surveys
(*d*) To connect two ends of an underground tunnel
(IES 2008)

175. Which one of the following methods is generally considered the best for tunnel ventilation?
(*a*) Driving a drift through the tunnel
(*b*) 'Blow in' method
(*c*) 'Blow out' method
(*d*) Combination of 'Blow in' and 'Blow out' methods
(IES 2007)

ANSWERS

1. (*a*)	**2.** (*b*)	**3.** (*c*)	**4.** (*b*)	**5.** (*c*)	**6.** (*d*)	**7.** (*b*)	**8.** (*d*)	**9.** (*c*)	**10.** (*d*)
11. (*b*)	**12.** (*b*)	**13.** (*c*)	**14.** (*c*)	**15.** (*a*)	**16.** (*a*)	**17.** (*b*)	**18.** (*b*)	**19.** (*c*)	**20.** (*b*)
21. (*d*)	**22.** (*c*)	**23.** (*d*)	**24.** (*c*)	**25.** (*d*)	**26.** (*c*)	**27.** (*c*)	**28.** (*c*)	**29.** (*b*)	**30.** (*d*)
31. (*c*)	**32.** (*b*)	**33.** (*d*)	**34.** (*b*)	**35.** (*c*)	**36.** (*b*)	**37.** (*b*)	**38.** (*b*)	**39.** (*d*)	**40.** (*c*)
41. (*a*)	**42.** (*c*)	**43.** (*c*)	**44.** (*d*)	**45.** (*d*)	**46.** (*d*)	**47.** (*a*)	**48.** (*c*)	**49.** (*d*)	**50.** (*d*)
51. (*d*)	**52.** (*d*)	**53.** (*c*)	**54.** (*a*)	**55.** (*c*)	**56.** (*a*)	**57.** (*c*)	**58.** (*a*)	**59.** (*d*)	**60.** (*d*)
61. (*c*)	**62.** (*a*)	**63.** (*c*)	**64.** (*a*)	**65.** (*a*)	**66.** (*b*)	**67.** (*d*)	**68.** (*d*)	**69.** (*d*)	**70.** (*c*)
71. (*a*)	**72.** (*a*)	**73.** (*b*)	**74.** (*b*)	**75.** (*c*)	**76.** (*c*)	**77.** (*d*)	**78.** (*b*)	**79.** (*a*)	**80.** (*c*)
81. (*a*)	**82.** (*a*)	**83.** (*d*)	**84.** (*c*)	**85.** (*c*)	**86.** (*b*)	**87.** (*c*)	**88.** (*c*)	**89.** (*c*)	**90.** (*b*)
91. (*a*)	**92.** (*a*)	**93.** (*b*)	**94.** (*a*)	**95.** (*b*)	**96.** (*c*)	**97.** (*a*)	**98.** (*b*)	**99.** (*d*)	**100.** (*d*)
101. (*c*)	**102.** (*b*)	**103.** (*a*)	**104.** (*c*)	**105.** (*a*)	**106.** (*b*)	**107.** (*a*)	**108.** (*c*)	**109.** (*c*)	**110.** (*c*)
111. (*a*)	**112.** (*c*)	**113.** (*b*)	**114.** (*c*)	**115.** (*c*)	**116.** (*c*)	**117.** (*a*)	**118.** (*c*)	**119.** (*b*)	**120.** (*a*)
121. (*d*)	**122.** (*d*)	**123.** (*a*)	**124.** (*b*)	**125.** (*d*)	**126.** (*c*)	**127.** (*b*)	**128.** (*a*)	**129.** (*a*)	**130.** (*b*)
131. (*b*)	**132.** (*a*)	**133.** (*b*)	**134.** (*b*)	**135.** (*c*)	**136.** (*c*)	**137.** (*d*)	**138.** (*d*)	**139.** (*d*)	**140.** (*c*)
141. (*c*)	**142.** (*b*)	**143.** (*b*)	**144.** (*a*)	**145.** (*c*)	**146.** (*c*)	**147.** (*d*)	**148.** (*c*)	**149.** (*a*)	**150.** (*a*)
151. (*d*)	**152.** (*b*)	**153.** (*d*)	**154.** (*a*)	**155.** (*b*)	**156.** (*b*)	**157.** (*c*)	**158.** (*b*)	**159.** (*b*)	**160.** (*b*)
161. (*b*)	**162.** (*d*)	**163.** (*c*)	**164.** (*b*)	**165.** (*a*)	**166.** (*b*)	**167.** (*b*)	**168.** (*b*)	**169.** (*c*)	**170.** (*b*)
171. (*c*)	**172.** (*d*)	**173.** (*c*)	**174.** (*d*)	**175.** (*d*)					