BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B.Tech (Civil)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Civil Engineering

Subject: Railways, Airport & Waterways (KCE 070)

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Unit - 2

Que 1. What is alignment and its types ? Discuss the basic requirements of a good alignment.

Answer:-

A **Alignment** : Alignment of railway line refers to the direction and position given to the centre line of the railway track on the ground in the horizontal and vertical plane.

B. **Type** : Following are the types of alignment :

1. **Horizontal Alignment:** It refers to the direction of the railway track in the plane including the straight path and the curves it follows.

2. **Vertical Alignment** : It refers to the direction, it follows in a vertical plane including the level track, gradients and vertical curves.

A. **Basic Requirements of a Good/Ideal Alignment:** Following are the requirements of good alignment :

1. **Purpose of the New Railway Line** : The purpose of constructing a new railway line may be one or more of the following :
   i. Strategic or political consideration.
   ii. Development of backward areas.
   iii. Shortening of existing rail lines.
   iv. Connecting the trade centres

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2. **Integrated Development:** The new railway line should fit in with the general planning and form a part of the integrated development of the country.

3. **Economic Considerations:** The construction of the railway line should be as economical as possible.

4. **Shortest Route** : The shorter is the length of the railway line, the lower would be the cost of its construction, maintenance and operation.

5. **Construction and Maintenance Cost** :

1. The alignment of the line should be so chosen that the construction cost is minimum.1bis can be achieved by a balanced cut and fill of earthwork, minimizing rock cutting and drainage crossings.

11. Maintenance costs can be reduced by avoiding steep gradients and sharp curves, which cause heavy wear and tear of rails and rolling stock.

6. **Minimum Operational Expenses:** The alignment should be such that the operational or transportation expenses are minimum. This can be achieved by providing easy gradients, avoiding sharp curves and adopting a direct route.

7. **Maximum Safety and Comfort:** This can be achieved by designing curves with proper transition lengths, providing vertical curves for gradients, and incorporating other such technical features.

Que 2. Enumerate the parameters which affect the geometric design of roads.

Answer:-

Parameters : Following are the parameters which affect the geometric design of roads:

1. Gradients in the track, including grade
2. compensation, rising gradient, and falling gradient. Curvature of the track, including horizontal and vertical curves, transition curves, sharpness of the curve in term of radius or degree of the curve, cant or super elevation on curves, etc.
3. Alignment of the track, including straight as well as curved alignment.

Que 3. Explain the necessity of gradients. Discuss all types of gradients giving their permissible values adopted in Indian Railways. (AKTU 2022-23, 10 Marks)

Answer:-

A. Necessity of Gradient:

1. Gradients are provided to negotiate the rise or fall in the level of the railway track.
2. Gradients are provided to meet the following bjectives:

i. To reach various stations at different elevations.

ii. To follow the natural contours of the ground to the maximum possible extent.

iii. To reduce the cost of earthwork

B. **Types of Gradient:** The following types of gradients areusedonthe railways:

I. **Ruling Gradient** :

L The ruling gradient is the steepest gradient that exists in a section.

i It determines the maximum load that can be hauled by a locomotive on that section.

ii Generally, the following ruling gradients are adopted by Indian Railways when there is only one locomotive pulling the train :

a In plain terrain :1 in 150 to 1 in 250.

b. In hilly terrain: 1 in 100 to **1** in 150.

1. Pusher or Helper Gradient :

L This is a steeper gradient than the ruling gradient. They are provided on track on mountainous regions to avoid heavy cuttings through rocks in order to reduce the route length.

u. These gradients require one or more additional locomotives for pulling the train load up the track.

w. In India at Bhorghat between Poona and Bombay a pusher gradient of 1 in 37 has been provided for a length of 4 km.

iv. It has been found that pusher gradient of 1 in 75 to 1 in 103 with additional one locomotive is generally sufficient.

2. Momentum Gradient:

i This is a rising gradient preceding falling gradient on which a moving train develops the momentum and kinetic energy for its negotiations.

ii This means that the momentum gradients are steeper than the ruling gradients.

iii. On a section of track provided with a momentum gradient, signals should not be provided to stop the train.

3. Gradients in Station Yards :

i This gradients in station yards are quite flat due to the following reasons :

a. It prevents standing vehicles from rolling and moving away from the yard due to the combined effect of gravity and strong winds.

b. It reduces the additional resistive forces required to start a locomotive to the extent possible.

ii The maximum gradient prescribed in station yards on Indian Railway is 1 in 400. while the recommended gradient is 1 in 1000.

Que 4. Explain the necessity of grade compensation at curves.

OR

What do you mean by the compensation for curvature on gradients ?

Answer

Grade Compensation :

1. In order to avoid resistances beyond the allowable limits, the gradients are reduced on curves and this reduction in gradients is known as grade compensation for curves.
2. The curve resistance is expressed as a percentage per degree of the curve.
3. The curve resistance is greater at lower speeds.
4. In India, compensation of curvature is given at 0.04 % per degree of curve for BG, 0.03 % for MG and 0.02 % for NG.
5. In terms of radius of curves in metres is 70/R for BG 52.5/R for MG and 35/R for NG.

Que 5. Write a short note on horizontal curves.

Answer

Horizontal Curves :

1. Horizontal curves are provided whenever there is change in the direction of the alignment of the track.
2. They are usually circular with parabolic transition curves at either end.
3. Horizontal curves are further classified into following parts:

Types : Following are the types of horizontal curves :

1. Simple Curve or Circular Curve :

i An arc of a circle is called simple curve.

ii. It is defined either by its radius or by its degree.

Degree of the curve is given by, $D = \frac{1750}{R}$ (R in metre]

[Degree of a curve is the angle subtended at its centre by a 30.5 m or 100 ft chord = $\frac{360}{2\pi R}$ x 30.5]

iii. This curve may lie within two transition curves or within two tangent lengths.

2. **Compound Curve** :

i. A compound curve is formed by the combination of two circular curves of different radii curving in the same direction.

ii. They are used when compelled by the topography to avoid the obstructions like hard rocks, deep cutting, soft gradients, etc.

3. **Reverse Curve** : A reverse curve is formed by the combination of two circular curves wi.th opposite curvatures with same or different radii.

4. **Transition Curve** :

i. The parabolic curve which is generally introduced between a straight and a circular curve is called a transition curve.

ii. Its radius varies from infinity at the point of commencement to the specified radius of the main circular curve at its junction.

Que 6. How do you define the superelevation ? What are the objects of providing superelevation on curves of a railway of track?

Answer

Superelevation :

1. 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.
2. This increases the weight on the outer rail.
3. 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.
4. This raised elevation of outer rail above the inner rail at a horizontal curve is called superelevation.

Objectives: The following are the objects of providing superelevation on curves:

1. To introduce the centripetal force for counteracting the effect of centrifugal force this will result in the faster movement of trains on curves. This will also prevent derailment and reduce the side wear and creep of rails.
2. To provide equal distribution of wheel loads on two rails so that there is no tendency of track to move out of position due to more load on outer rails. This reduces the wear of rails, equipment and results insaving in maintenance cost.
3. To provide an even and smooth running track to ensure comfortable ride to passengers and safe movement of goods.

Que 7. Derive the relation of superelevation with gauge, speed and radius of the curve.

Answer

1. Let,

W = Weight of the moving vehicle in kg.

v = Speed of vehicle in m/sec.

V = Speed of vehicle in km/h.

R = Radius of curve in m.

G = Gauge of track in m.
g = Acceleration due to gravity in m/sec^2.
α = Angle of inclination.
S = Length of inclined surface in m.

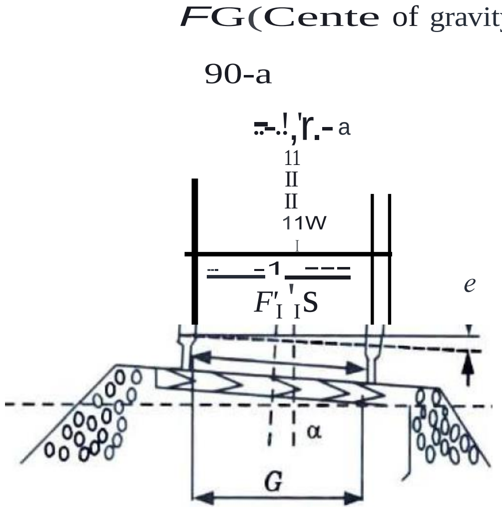


Fig. 2.7.1. Relationship between superelevation, gauge and curve.

2. Centrifugal force is given by,

$$F = \frac{Wv^2}{gR} \quad ...(2.7.1)$$

3. Now resolving the forces along the inclined surface, we get

$$F \cos \alpha = W \sin \alpha \quad ...(2.7.2)$$

where, $F = \frac{Wv^2}{gR}$, $\cos \alpha = \frac{G}{S}$, $\sin \alpha = \frac{e}{S}$

4. ∴ Eq. (2.7.2) becomes, $\frac{Wv^2}{gR} \times \frac{G}{S} = W \times \frac{e}{S}$

$$e = \frac{v^2}{gR} \times G \text{ in m, where } v \text{ is in m/sec.}$$

$$= \frac{G \times (0.278)^2\, V^2}{9.81\, R} \text{ m, where } V \text{ is in kmph}$$

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

where, G is in m, V is in km/h and R is in m.

5. In India, G for BG = 1.676 m, MG = 1 m, NG = 0.762 m

6. For BG, $e = \frac{1.676\, V^2}{1.27\, R} = \frac{1.319\, V^2}{R}$ cm

For MG, $e = \frac{1\, V^2}{1.27\, R} = \frac{0.8\, V^2}{R}$ cm

For NG, $e = 0.762\, V^2 = 0.6\, V^2$ cm

Que 8. Write short note on :

A. Equilibrium Cant.
B. Cant Deficiency.
C. Negative Superelevation / Cant.

Answer

A Equilibrium Cant:

1. A state of equilibrium is reached when both the wheels exert equal pressure on the rails and the superelevation is enough to bring the resultant of the centrifugal force and the force exerted by the weight of the vehicle at right angles to the plane of the top surface of the rails.

2. In this state of equilibrium, the difference in the heights of the outer and inner rails of the curve is known as equilibrium superelevation.

B. Cant Deficiency:

1. It is the difference between the equilibrium cant necessary for the maximum permissible speed on a curve and the actual cant provided (on the basis ofaverage speed of trains).

2. 'This cant deficiency is limited due totwo reasons :

i. High cant deficiency gives rise to higher discomfort to passengers.

ii. High cant deficiency means higher would be the balanced centrifugal force and hence extra pressure and lateral forces on outer rails. This will require strong track and fastenings for stability.

Gauge	Normal Cant Deficiency (Speed upto 100 km/h)	Cant Deficiency (Speed higher than 100 km/h)
BG	76mm	100mm
MG	51mm	not specified
NG	38mm	not specified

C. Negative Superelevation / Cant :

1. When the main line lies on a curve and has a turnout of contrary flexure leading to a branch line, the superelevation necessary for the average speed of trains running over the main line curve cannot be provided.

2. In Fig. 2.8.1, AB, which is the outer rail of the main curve, must be higher than CD.

3. For the branch line, however, CF should be higher thanAE or point *C* should be higher than point A.

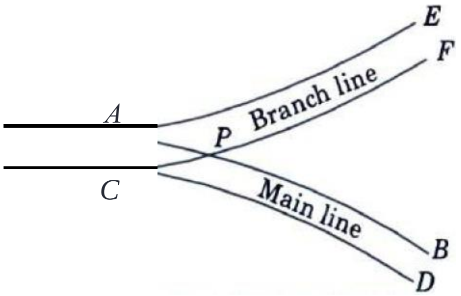


Fig. 2.8.1. Negative superelevation.

4. These two contradictory conditions cannot be met within one layout.

5. In such cases, the branch line curve has a negative superelevation and, therefore, speeds on both tracks must be restricted, particularly on the branch line.

6. The provision of negative superelevation for the branch line and the reduction in speed over the main line can be calculated as follows :

i. The equilibrium superelevation for the branch line curve is first calculated as,

$$e = \frac{Gv^2}{127\ R}$$

ii. The equilibrium superelevation *e* is reduced by the permissible cant deficiency *Cd* and the resultant superelevation to be provided is

i. $x = e - Cd$

The value of *Cd* is generally higher than that of e, and therefore, *x* is normally negative. The branch line thus has a negative superelevation of *x*.

iii. The maximum permissible speed on the main line, which has a superelevation of *x*, is then calculated by adding the allowable cant

deficiency (x + Cd). The safe speed is also calculated and the smaller of the two values is taken as the maximum permissible speed on the majn line curve.

Que 9. Determine the equilibrium cant on a 2° curve on a broad gauge, if 16 trains, 10 trains, 8 trains, 4 trains and 2 trains are running at a speed of 50 kmph, 60 kmph, 70 kmph, 80 kmph and 100 kmph respectively. Also, determine the deviation from maximum speed. (AKTU 2018-19, 10 Marks)

Answer

Given: Degree of curve= 2°, Gauge, G = 1.676 m

To Find: Equilibrium cant and Deviation from maximum speed.

1. The "weighted average" of ilifferent trains at ilifferent speeds is calculated as

$$\text{Weighted average} = \frac{n_1 V_1 + n_2 V_2 + n_3 V_3 + n_4 V_4 + n_5 V_5}{n_1 + n_2 + n_3 + n_4 + n_5}$$

$$= \frac{16 \times 50 + 10 \times 60 + 8 \times 70 + 4 \times 80 + 2 \times 100}{16 + 10 + 8 + 4 + 2} = 62 \text{ kmph}$$

2. Deviation from maximum speed= {100- 62) kmph = 38 kmph

3. Equilibrium cant is given by,

$$e = \frac{GV2}{1.27\ R}$$

$$= \frac{1.676 \times 62^2}{1.27 \times 860} = 5.9 \text{ cm} \quad (\because R = \frac{1720}{2} = 860 \text{ m})$$

Que 10. In a layout of a BG yard, an 8° curve diverges from a 5° main curve. If **the maximum permissible speed on the main curve is 65 kmpb, determine the restricted speed on diverging curve. (AKTU 2018-19, 10 Marks)**

Answer

Given: Degree of rnverge curve= 8°, Degree or' main curve= 5°, Maximum permissible speed = 65 kmph, Gauge, G = 1.676 m

To Find: Restricted speed on diverging curve.

1. Radius of main line curve, $R_M = \frac{1720}{D} = \frac{1720}{5} = 344$ m

2. Equilibrium superelevation is given by, $e = \frac{GV^2}{1.27R}$

$$e = \frac{1.676 \times 65^2}{1.27 \times 344} = 16.20 \text{ cm}$$

3. Actual superelevation on main line (e_{act})

= Equilibrium cant - Cant deficiency

= 16.20 - 7.6 = 8.6 cm

∴ For BG track, cant deficiency for main line = 7.6 cm

4. The value of negative super elevation on branch line

= - eact at main line= - 8.6 cm

5. eact at branch line = - 8.6 + 7.6 = - 1

6. Speed restriction on branch line of diverging curve,

$$e = \frac{GV^2}{1.27R} \quad R = \frac{1720}{D} = \frac{1720}{8} = 215 \text{ m}$$

$$V = \sqrt{\frac{1.27\, e \times R}{G}} = \sqrt{\frac{1.27 \times 1 \times 215}{1.67}} = 12.76 \text{ k.mph}$$

Que 11. How the maximum permissible speed of the train is determined on a curved railway track in India ?

Answer

1. Safa speed refers to a speed which protects a carriage from the danger of overturning and derailment and provides a certain margin of safety.
2. It was calculated empirically by applying Martin's formula.

i. **For BG and MG :**

a. Transitioned curves:

$$V = 4.4\sqrt{R - 70}$$

where, V is the speed in kmph and R is the radius in m.

b. Non-transitioned curves :

Safe speed= Four-fifths of the speed calculated using eq. (2.11.1)

ii. **For NG:**

a. Transitioned curves :

$V = 3.65\sqrt{R - 6}$ (Subject to a maximum of 50 k.mph) ...(2.11.2)

b. Non-transitioned curves:

$V = 2.92\sqrt{R - 6}$ (Subject to a maximum of 40 kmph) ...(2.11.3)

3. New formula for determining maximum permissible speed on transitioned curves :

i. **For BG:**

...(2.11.4)

$$V = \sqrt{\frac{(Ca+Cd) \times R}{13.76}} = 0.27\sqrt{(Ca+Cd) \times R}$$

where,

V = Maximum speed (kmph).

Ca = Actual cant (mm).

Cd = Permitted cant deficiency (mm).

R = Radius (mm).

ii. **For MG:**

$$V = 0.347\sqrt{(C_a + C_d) \times R} \quad ...(2.11.5)$$

This is based on assumption that the centre-to-centre distance between the rail heads of an MG track is 1058 mm.

iii. **For NG:**

$V = 3.65$ JCR - 6) (Subject to a maximum of 50 kmph) ...(2.11.6)

4. The maximum speed on curves without transition is now based on concept of virtual transitions (This virtual transition distance is 14.6 m on BG,13.7 m on MG and 10.3 m on NG) so the safe speed is worked out on the basis of cant and permissible amount of cant deficiency as applicable.

5. The cant gi-adient over transition distance specified should not exceed 1 in 360 (2.8 mm/m) on BG and 1 in 720 (1.4 mm/m) on MG and NG.

Que 12. On a BG 3° curve the equilibrium cant is provided for a speed of 70 kmph. alculate the value of equilibrium cant and allowable cant deficiency. What would be the maximum permissible speed on the track?

Given : Degree of curve = 3°, Speed, V = 70 kmph
To Find: Equilibrium cant, allowable cant deficiency and maximum permissible speed.

1. Equilibrium cant as given by the equation

$$e = \frac{G \times V^2}{1.27 \times R} = \frac{1.676 \times 70^2}{1.27 \times 573.33} = 11.28 \text{ cm} \quad (\because R = \frac{17}{:0} = 573.33 \text{ m})$$

2. Theoretical cant = Equilibrium cant + Cant deficiency

= 11.28 + 7.60 = 18.88 cm

3. Permissible speed, $V = \frac{1.27 \times ex\ R}{1.676} = \frac{1.27 \times 18.88 \times 573.33}{1.676}$

= 90.57 kmph

4. According to Railway Board's speed formula,

V = 4.35 JR - 67 = 4.35 J573.33 -67 = 4.35 x 22.6 = 98 kmph

Hence, maximum permissible speed (*i.e.*, lower of the two values) = 90.57 k.mph, say 90 kmph

Que 13. Calculate the super elevation, maximum permissible speed, and transition length for a 3° curve on a high - speed BG section with a maximum sanctioned speed of 110 kmph. Assume the equilibrium speed to be 80 kmph and the booked speed of the goods train to be 50 kmph. (AKTU 2018-19, 10 Marks)

Answer

Given : Degree of curve = 3°, Sanctioned speed = 110 kmph, Equilibrium speed= 80 k.mph, Booked speed= 50 k.mph

To Find : Superelevation, maximum permissible speed and length of transition curve.

1. Radius of curve, $R = \frac{1720}{D} = \frac{1720}{3} = 573.33$ m

2. Equilibrium superelevation for 80 kmph,

$$= \frac{aV^2}{127R} = \frac{1150 \times 80^2}{127 \times 573.33} = 153.82 \text{ mm}$$

3. Equilibrium superelevation for maximum sanctioned speed (110 kmph)

$$= \frac{1750 \times 110^2}{127 \times 573.33} = 290.81 \text{ mm}$$

4. Cant deficiency= 290.81 mm - 153.82 mm = 137 mm
This value of cant deficiency is more than 100 mm (the permitted value of *Cd*), therefore, take *Cd* as 100 mm. Now,
Actual cant= 290.81-100 = 190.81 mm
However, actual cant is to be limited to 165 mm, and, therefore, this value will be adopted.

5. Equilibrium superelevation for a goods train with a speed of 50 kmph

$$= \frac{1750 \times 50^2}{127 \times 573.33} = 60.10 \text{ mm}$$

6. Cant excess = actual cant - 60.10 mm
= 165 - 60.1 = 104.90 mm
which is in excess of 75 mm -the permitted value. With 75 mm taken as cant excess, the actual cant to be provided now is 75 + 60.1 mm= 135.10 mm.
Therefore, a cant of 135 mm should be provided (rounding off to the higher multiple of 5).

7. Safe speed er speed potential (for high-speed route)

$$= 0.27\sqrt{(Ca + Cd) \times R}$$

$$= 0.27\sqrt{(035 + 100) \times 573.33} = 99.1 \text{ kmph}$$

(or approx. 100 kmph)

8. Maximum permissible speed on the curve is the least of the following:
   1. Maximum permissible speed of the section, *i.e.*, 110 kmph
   2. Safe speed on the curve, *i.e.*, 100 kmph The maximum permissible speed on the curve is, therefore, 100 kmph.

9. The length of transition is the maximum value from among the following:
   i. When taking the rate of change of cant into consideration (35 mm/ sec),
   $L = 0.008\,(Ca \times Vm) = 0.008 \times 135 \times 100 \text{ m} = 108 \text{ m}$
   ii. When taking the rate of change of cant deficiency into consideration (35 mm/sec),
   $L = 0.008\,(Cd \times Vm) = 0.008 \times 100 \times 100 \text{ m} = 80 \text{ m}$
   iii. When taking the cant gradient into consideration (1 in 720),
   $L = 0.72 \times e = 0.72 \times 135 \text{ m} = 97.2 \text{ m}$

Therefore, the superelevation to be provided is 135 mm, the maximum permissible speed over the curve is 100 kmph, and the length of transition curve is 108 m.

Que 14. Calculate the superelevation and the maximum permissible speed for a 2° BG transitioned curve on a high-speed route with a maximum sanctioned speed of 110 kmph. The speed for calculating the equilibrium superelevation as decided by the chief engineer is 80 kmph and the booked speed of goods trains is 50 kmp

(AKTU 2017-18, 10 Marks)

Answer

Given: Transitioned curve = 2°, Sanctioned speed= 110 kmph, Equilibrium superelevation speed = 80 kmph, Booked speed = 50kmph

To Find : Superelevation and maximum permissible speed.

1. Radius of curve, $R = \frac{1720}{D} = \frac{1720}{2} = 860$ m

2. Supere1e 1 vati'on ",or eqw ·1·b 1 r'nnn spee d = $\frac{GV_R^2}{127}$

Actual cant (Ca), $e = \frac{1750 \times 80^2}{127 \times 860} = 102.55$ mm

3. Superelevation for maximum sanctioned speed (110 kmph):

$$e = \frac{GV^2}{127R} = \frac{1750 \times 110^2}{127 \times 860} = 193.87 \text{mm}$$

4. Cant deficiem:y, Cd= 193.87 -102.55 = 91.32 mm (Which is less than 100 mm and hence permissible).

5. Superelevation for goods trains with a booked speed of 50 kmph,

$$e = \frac{GV^2}{127R} = \frac{1750 \times 50^2}{127 \times 860} = 40.0S \text{ mm}$$

Cant excess, Ca= 102.55 -40.05 = 62.50 mm (which is less than 75 mm and hence permissible).

6. Maximum speed potential or safe speed of the curve as per theoretical considerations, being a high-speed route :

$$V = \sqrt{\frac{(Ca+Cd) \times R}{13.76}} = 0.27\sqrt{(Ca + Cd) \times R}$$

$$V = \sqrt{\frac{(102.55 + 91.32) \times 860}{13.76}} = 110 \text{ kmph}$$

7. The maximum permissible speed on the curve is the least ofthe following:

i. Maximum sanctioned speed, *i.e.*, 110 kmph

ii. Maximum or safe speed over the curve based on the theoretical consideration i.e., 110 kmph.

iii. There is no speed constraint due to the transition length of the curve. Therefore, the maximum permissible speed over the curve is 110 kmph and the superelevation to be provided is 102.55 mm.

Que 15.What is a transition curve? What are the different types **and what are the requirements for an ideal transition curve** ?

(AKTU 2018-19, 10 Marks)

Answer

A. Transition Curves:

1. Transition curve is defined as a curve of parabolic nature which is introduced between a straight and a circular curve or between two branches of a compound curve.

2. Its radius rises from infinity toa selected minimum in order to attain full superelevation and curvature gradually. This is also known as spiral or easement curve.

B. Requirements : Following are the requirements of ideal transition curve:

1. It should be perfectly tangertial to the straight.
2. The length of the transition curve should be such that curvature may increase at the same rate as the superelevation. This is necessary to attain the full superelevation at the junction of transition and circular curve.
3. This curve should join the circular arc tangentially *i.e.*, curvature of transition curve should conform to that of circular curve.

C. Types of Transition Curves : There are follo.ving three types of transition curves :

1. Spiral Curve: This is an ideal transition curve. Radius of this curve is inversely proportional to length traversed. Hence the rate of change of acceleration in this curve is uniform throughout its length.

2. Cubic Parabola : In case of this curve the rate of decrease of curvature is much low for deflection angles 4° to 9° but beyond 9° there is a rapid increase in the radius of curvature.This curve is easy to lay in the field and hence widly adopted by Indian Railways. The curve can be expressed by the following equation.

$$y = \frac{xa}{6RL}$$

where, x and y = Coordinates of any point on the curve.
R = Radius at any point on the curve in metres.
L = Length of the curve from the origin to any point on the curve in metres.

3. **Bernoulli's Lemniscate Curve** : In this transition curve, radius decreases as the length increases and hence there is slight falling of the rate of gain of radial acceleration. The curve can be expressed by the following equation :

$$L = C \sin^2 h$$

where, L = Length of polar ray in metres.
h = Polar angle in radians.
C = Constant.

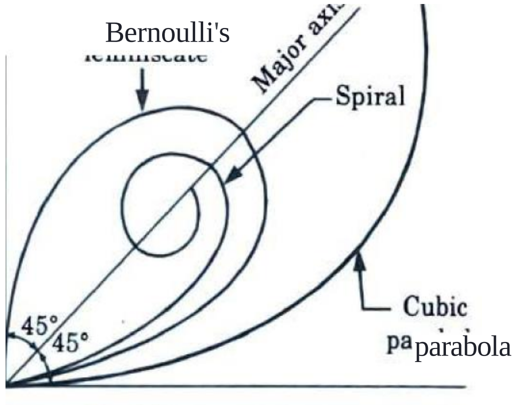


Fig. 2.15.1. Types of transition curves.

Que 16. What are the object!ves of providing transition curves on railways ? Explain as to how the length of transition curve is decided?

Answer

A. Objectives of Providing Transition Curves on Railways :

1. To decrease the radius of curve gradually from infinite at the straight to that of circular curve of selected radius. This is applicable to both inner and outer rails.
2. To attain gradual rise for the desired superelevation. This is applicable for outer rails only.
3. The gradual increase or decrease of the centrifugal force on the vehicle by use of this curve provides smooth running of vehicles and comfort to the passengers.
4. No sudden application or releasing of the force is encountered so the chances of derailment are gre11tly reduced.

B. Length of Transition Curve :

1. The length of the transition curve is length along the centre line of the track from its meeting point with the straight to that of the circular curve.
2. This length is inserted at the junction half in the straight and half in the curve (as shown in Fig. 2.16.1).
3. Let, L = Length of transition curve in metres.

   e = Actual cant or superelevation in cm.

   D = Cant deficiency for maximum speed in cm.

   V = Maximum speed in kmph.

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

   l. Formula based on arbitrary gradient (1 in 720),

   $$L = 7.20e$$

   where, e = Actual superelevationin cm.

   IL Formula based on the rate of change of cant deficiency,

   $$L = 0.073D \text{ x } v_{max}$$

   where, D = Cant deficiency for maximum speed in cm.

   V_{max} = Maximum speed ink.mph.

   Ill. Formula based on the rate of change of superelevation,

   $$L = 0.013e \text{ x } V_{max}$$

5. By another approach the length of the transition curve is obtained by the maximum value of the following values :

   i. AB per railway code,

   $$L = 4.4\ Jii$$

   where, R = Radius of curve.

   ii. At the rate of change of superelevation of 1 in 360 *i.e.*, 1 cm for every 3.6 m.

iii. Rate of change of cant deficiency, say 2.5 cm, is not exceeded.

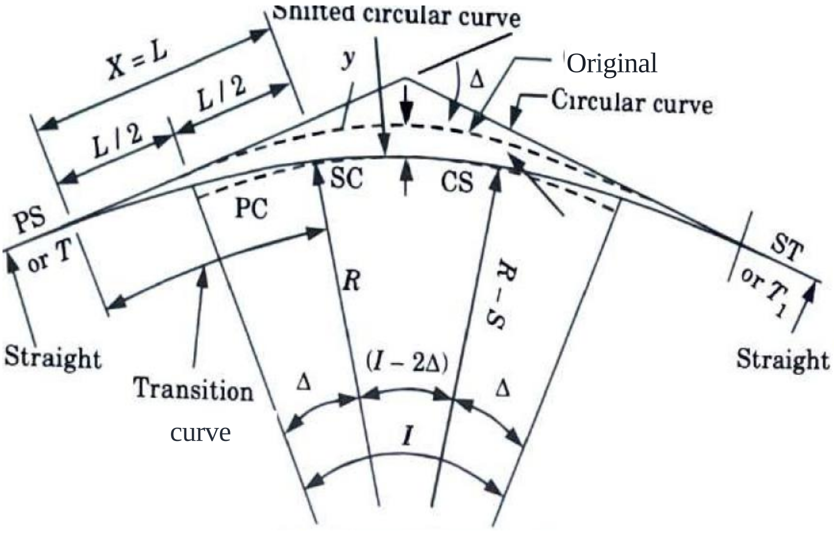


Fig. 2.16.1. Layout of transition curve.

iv. Based on rate of change of radial acceleration with radial acceleration of 0.3048 m/sec^2

$$L = \frac{3.28v^2}{R} \text{ metres}$$

where, R and L are in metres, v = 0.278 V
where, V is in kmph and v = m/sec

Que 17. Why is the widening of gauge required on sharp curves?

OR

A vehicle moving on a BG track has a wheelbase of 4.724 m, Diameter of the wheel is 1524 mm. flanges project 32 mm below top of rail. Radius of curvature is 168 m. Determine extra width of flange. (AKTU 2016-17, 10 Marks)

Answer

A. Widening of Gauge on Curves :

1. Due to rigidity of the wheel base, when the outer wheel of the front axle strikes against the outer rail, the outer wheel of the inner axle bears a gap with the outer rail.
2. Provision should be made for this gap, otherwise there is every possibility of tilting rails outwards.
3. This gauge widening should be just adequate, if it is more than required, the lateral play of the vehicles will be vigorous and may result in derailment.
4. Extra width of gauge (d) in cm is given by the formula :

$$d = \frac{13(B + L)^2}{R}$$

where, B = Rigid wheel base in metres.

For BG track, $B = 6$ m

For MG track, $B = 4.88$ m

R = Radius of the curve in metres.

L = Lap of flange in metres.

$$d = \frac{13(B + L)^2}{R}$$

y.

where, B = Rigid wheel base in metres.

For BG track, $B = 6$ m

For MG track, $B = 4.88$ m

R = Radius of the curve in metres.

L = Lap of flange in metres.

$$L = 0.02\sqrt{h^2 + Dh} \text{ metres.}$$

where, h = Depth of wheel flange below rail top level in cm.

D = Diameter of wheel in cm.

Numerical:

Given: Wheel base, B = 4.724 m, Diameter of wheel, D = 1524 mm = 152.4 cm, Flange projection, h = 32 mm= 3.2 cm, Radius of curvature, R = 168 m

To Find : Extra width of flange.

Extra width of flange is given by, $L = 0.02 \times \sqrt{h^2 + D \times h}$ meter

$$L = 0.02 \times \sqrt{(3.2)^2 + 152.4 \times 3.2} = 0.446$$

Que 18. What are the extra clearances provided on a curved track? Describe the extra clearance provided between two adjacent curved tracks.

Answer

A. **Extra Clearance on Curves** : Extra clearances are provided on horizontal curves keeping the following considerations in mind :

1. **Effect of Curvature** :

The distance by which the longitudinal axis of the body of the vehicle moves out from the central line of the track is the extra clearanc required.

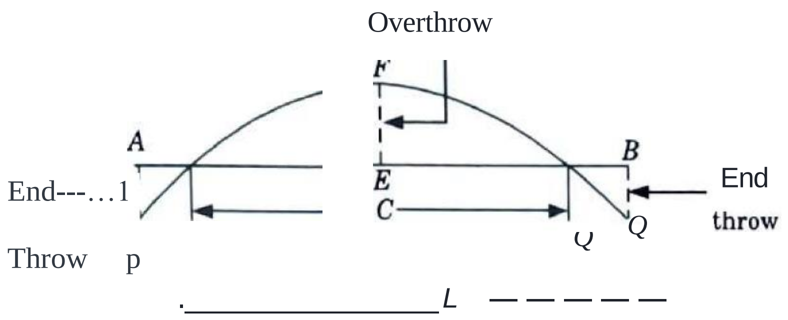


Fig. 2.18.1. Effect of curvature on long vehicle.

i. **The** extra clearance required at the centre of the vehicle, which projects towards the inside of the curve, is called overthrow and is given by the equation:

$$EF = \frac{c^2}{BR}$$

ii. **The** extra clearance required at the ends of the vehicle, which projects towards the outside of the curve, is called end-throw and is given by the equation.

$$AP \, or \, BQ = \frac{L^2 - c^2}{BR}$$

where, L = Length of the vehicle.
C = Centre to centre distance between the bogies.
R = Radius of the curve.

2. **Effect of Leaning due to Superelevation**:

L The extra clearance required for leaning is as follows :

$$\text{Lean} = \frac{he}{a}$$

Where, h = Heightofthevehicle.
e = Superelevation.
G = Gauge.

3. **Effect of Sway of Vehicles** : The extra clearance required on the inside of the curve due to the sway is taken as one-fourth of the clearance necessary due to leaning.

1. On summarizing, the total extra clearance (in mm) required on curves is as follows :

L Extra clearance inside the curve = Overthrow + Lean + Sway

$$E_{ct} = \frac{C^2}{BR} + \frac{eh}{G} + \frac{1}{4} \times \frac{eh}{G}$$

11. Extra clearance outside the curve = End throw

$$E_2 = \frac{L^2 - C^2}{BR}$$

B. The empirical formulae normally adopted in the field for determining the extra clearance due to the curvature effect are shown in table 2.18.1.

Table 2.18.1: Extra clearance on horizontal curves.

	BG	MG
Overthrow (mm}	*27,33<YR*	23,516"R
End throw (mm)	29,600/R	24,063/R

These empirical formulae are based on standard BG and MG bogie lengths and the value of R is in metres.

Que 2.19, Two high level platforms are to be provided on the inside as well as the outside of a 2° curve on a BG track with a super elevation **of 100 mm. What should be the required extra clearances for these platforms, both** on **the inside and the outside of the curve? (Length of bogie = 21,340 mm,** *c/c* **bogie distance= 14,785 mm, height of platform =840mm).**

Answer

Given: Degree of curve= 2°, Superelevation, e = 100 mm
Length of bogie = 21,340 mm, *de* bogie distance, c = 14785 mm, Height of platform, h = 840mm

To Find: Required extra clearance of between platforms.

1. Radius of the curve,

$$R = \frac{1720}{D} = \frac{1720}{2°} = 860 \text{ m}$$

2. Extra clearance required on the inside of the curve,

$$Ec1 = \text{Overthrow} + \text{Lean} + \text{Sway} - 51 \text{ mm}$$

$$= \frac{C^2}{8R} + \frac{eh}{G} + \frac{1}{4} \times \frac{eh}{G} - 51 \text{ mm}$$

$$Ec1 = \frac{14785^2}{8 \times 860{,}000} + \frac{100 \times 840}{1676} + \frac{1}{4} \times \frac{100 \times 840}{1676} - 51 \text{ mm}$$

= 43.5 mm ,,,45rnm

3. Extra clearance required on the outside of the curve

$$Ec_2 = \text{End throw} - 25 \text{ mm} = \frac{L^2 - c^2}{8R} - 25$$

$$\frac{21340^2 - 14785^2}{8 \times 860{,}000} - 25 = \text{g.4''' } 10 \text{ mm}$$

Que 20. Explain the various technical terms used in points and crossings.

Answer

Following are the technical terms used in points and crossings :

1. **Facing Direction:** If someone stands at toe of switch and looks towards the crossing, then the direction is called "Facing Direction".
2. **Trailing Direction** : If someone stands at the crossing and looks towards the switches, then the direction is called "Trailing Direction".
3. **Facing Point of Turnouts** : These are those where trains pass over the switches first and then they pass over the crossing. These are important to specify when the direction of movement of trains is reserved for facing direction.
4. **Trailing Points of Turnouts** :
   1. These are those on the opposite side of facing points in which the trains pass over the crossing first and then over the switches. These are important to specify when the direction of movement of trains is reserved for trailing direction only.
   11. So every point may be 'facing' or 'trailing' point or both, depending upon the direction of movement of trains.
5. **Right-Hand and Left-Hand Turnouts** :
   1. If a train from main track is diverted to the right of the main route in the facing direction then this diversion is known as right-hand turnout.
   u. If a train from main track is directed to the left of the main route in the facing direction, then the diversion is known as left-hand turnout.
6. **Right-Hand and Left-Hand Switches** : These are termed as left- hand or right-hand swiu-hes depending upon the left or right when seen from the facing direction *i.e.*, stand at the points and looks towards the crossing.

7. **Toe of Switch or Toe of tongue Rail:** It is the movable portion of the tongue rail having tapered end.
8. **Heel of Switch:** This is the untapered end of switch rail which is fixed to the mail rail.
9. **Throw of Switch** : This is the distance through which the toe of the tongue rail moves sideways when operated. Thus it is the clear gap between the running face of the stock rail and the toe of the tongue rail. Its value is generally kept as 11.4 cm.
10. **Heel Divergence:** This is measured as a distance between the running face of the stock rail and that of the tongue rail at heel of the switch.
11. **Lead Rails** : They are the rails which lead the track from heel of the tongue rails to the toe of crossings.
12. **Wing Rails** : These are the bent up lengths of rail used in front of nose of crossing which help in channelizing the wheels in their proper routes.
13. **Splice Rail** : This is the rail of the branch track meeting at the nose of crossing.
14. **Nose of Crossing:** This is the point of intersection of intersection point rail and splice rail.
15. **Angle of Crossing** : This is the angle between the rwming faces of point rail and splice rail at a crossing.
16. **Check Rail** : These are the rail lengths provided, on the opposite sides of the crossing to check the tendency of the wheel to climb over the crossing.
17. **Toe of Crossing:** This is the end point of a wind rail with lead rail.
18. **Heel of Crossing:** This is the end of the point of splice rail at a crossing.
19. **Slide Chairs** : These are the plates to support the tongue rails throughout their length. This allows there to slide laterally when changing the points.

Que 21. Draw a neat sketch showing a right hand turnout and name its components.

Answer

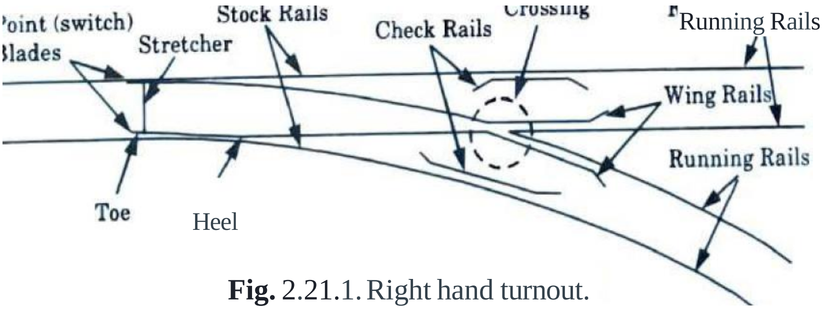


Fig. 2.21.1. Right hand turnout.

1. Turnout is the simplest combination of points and crossings which enables one track, either a branch line or a siding, to take off from another track.

2. The object of turnout is to provide facilities for same movement of trains in either direction on both the tracks.
3. Following are the components of turnout:

i. A pair of points or switches.

ii. A pair of stockrails.

iii. A Vee crossing.

iv. Two check rails.

v. Four lead rails.

vi. "Switch tie-plate" or "gauge tie chair" and "crossing tie-plate".

vii. Studs or stops.

viii. Bearing plates, slide chairs, stretcher bars, etc.

ix. For operating the points-rods, cranks, levers, etc.

x. For locking system-locking box, lock bar, plunger bar, etc

Que 22. Discuss the methods for design calculations of turnouts.

Answer

Different Methods of Turnout Design : The following three methods are used for designing the turnouts :

Method I : The important features of this method are :

1. All the three-leads, *i.e.*, *CL*, *SL* and *L* are calculated in this method. The *CL* and *SL* are peculiar for this method and will not be calculated in the other two methods.

2. Crossing angle (a) in this method is calculated or used by right angle method.

3. In this simple design of turnout, a crossing curve is considered to start from an imaginary tangent poilit ahead of actual toe of the switch and end at TNC. This arrangement results in the formation of three kinks, namely:

   i. A kink at the toe of switch. This is because the tongue rail is straight.

   ii. A kink at the heel of switch. This is because the tongue rail is not tangential of the curve.

   iii. A kink at the toe of crossing. This is because the curve is carried theoretically upto TNC but the crossing actually is straight.

4. This method of design includes all the three kinds of kinks and was common in the past. At present, its use is confined to sidings, light-section rails and unimportant lines.

Design-Calculations of Method I : With the given values of gauge (G), heel-divergence *(d)* and angle of crossing (a.), the turnout is designed as folJows (Fig. 2.22.1) :

1. Curve Lead (CL) :
For triangle TBC,

$$\tan\frac{\alpha}{2} = \frac{BC}{TB} = \frac{G}{CL}$$

$$CL = \frac{G}{\tan\frac{\alpha}{2}} = G\cot\frac{\alpha}{2} \qquad ...(2.22.1)$$

Also $CL^2 = G(2R_0 - G)$ [From geometry of th Fig. 2.22.11

$$= 2R_0G - G^2$$

TNC Heel of switch Toe of switch

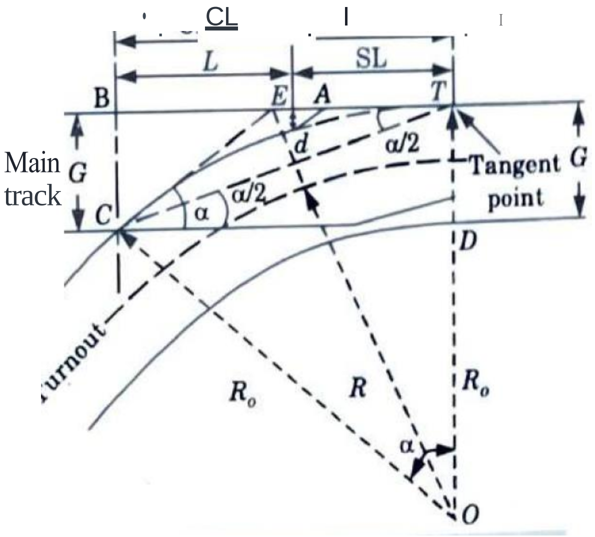


Fig. 2.22.1. Method *I*, for de ign of turnout.

Neglecting G^2 which is very small as compared to 2*RG*.

$CL = \underline{J2Rp}$ if R_0 is given. ...(2.22.2)

Also $CL = BE + ET = BE + EC$ $(\because EC = ET)$

$= G \cot a + G \operatorname{cosec} a = aJn\overline{+\cot^2 a)} + G \cot a$

$= \underline{GJ(l+N2)} + GN$ $(\because \cot a = N)$

$CL = 2GN$

I∵ $N =$ cot a, right angle method and $\underline{J1+N}^{2} = =N$ 1

2. R-Radius : From *!),QCD,*

$\sin a = \frac{DC}{OC} = \frac{TB}{R_0} = \frac{CL}{R_0}$

or $R = -\frac{CL}{\sin a}$ ...(2.22.3)

$_0$

Hence $R_0 = R_0 - \frac{G}{2}$ ...(2.22.4)

Also $R_0 = TD + DO$

$= G + CL \cot ex$

Since $CL = 2GN$

and $\cot ex = N$

$R_0 = G + 2GN2$

Because CLis actually slightly greater than 2GN and hence more accurate value of R_0 is given by the following equation :

$R_0 = 1.5\ G + 2GN2$ If'*N* is given ...(2.22.5)

Again $R = R_0 - \frac{G}{2}$ ...(2.22.6)

3. Switch-Lead (SL):

$SL^2 = d(2R_0 - d)_0 = 2R\ d\text{-<}11\text{-}$

$$SL = \sqrt{2R_0 d} \qquad \ldots(2.22.7)$$

[Neglecting d^2, very small than $2R_0d$]

4. Lead or Crossing Lead (L) :

$$L = CL - SL = G\cot(\alpha/2) - \sqrt{2R_0 d}$$

$$= \sqrt{2R_0 G} - \sqrt{2R_0 d}$$

5. Heal Divergence (d): From eq. (2.22.7), we get

$$d = \frac{SL^2}{2R_0}$$

Method II : The important features of this method are :

1. Only the crossing lead, *i.e.*,'*L*' is calculated.
2. In this method, the curve is tangential to the tongue rail. It springs up from the heel of switch and ends at TNC.
3. With the help of this method, out of three types of kinks, a kink which is formed at the heel of switch is removed.

Design-Calculations of Method II : With the given values of gauge (G), *d*, β (angle of switch) and α, the turnout is designed as follows:

1. **Lead or Crossing Lead (L)** : From Δ *TDC*,

$$\tan\frac{\alpha+\beta}{2} = \frac{G-d}{L}$$

$$L = \frac{G-d}{\tan\frac{\alpha+\beta}{2}} = (G-d)\cot\frac{\alpha+\beta}{2} \qquad \ldots(2.22.8)$$

2. **R-Radius :**

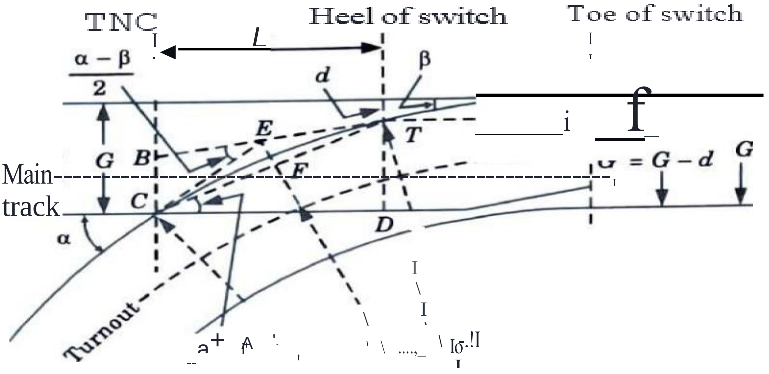
$$\angle COF = \frac{\alpha-\beta}{2}$$

where *O* is the centre of the curve.

$$\therefore \sin\frac{\alpha-\beta}{2} = \frac{CF}{R_0} = \frac{CT}{2R_0}$$

$$= \frac{\frac{TD}{\sin\frac{\alpha+\beta}{2}}}{2R_0} = \frac{(G-d)}{2R_0\sin\frac{\alpha+\beta}{2}}$$

$$R_0 = \frac{G-d}{2\sin\frac{\alpha+\beta}{2}\sin\frac{\alpha-\beta}{2}}$$



$\frac{\alpha+\beta}{2}$

$\frac{\alpha-\beta}{2}$

α−β

Fig. 2.22.2. Method II, for design of turnout.

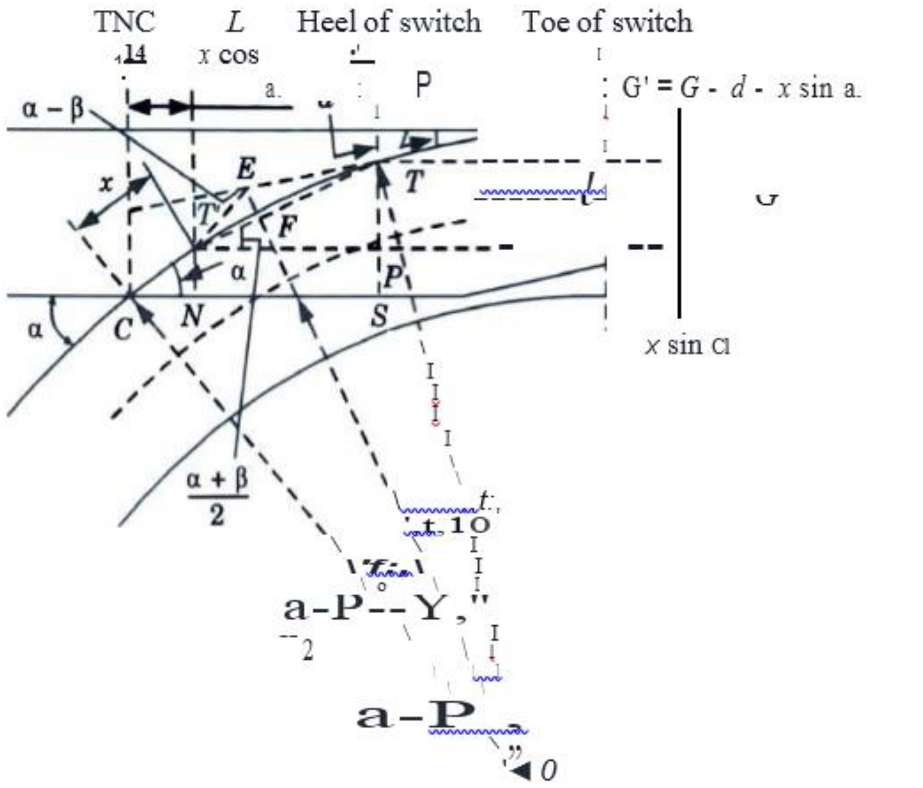
$$R_o = \frac{G-d}{\cos P - \cos a} \qquad \text{...(2.22.9)}$$

and $R = R_o - G/2$ ...(2.22.10)

Method,JII: The important features of this method are:

1. This method is very similar to method II. But in this case, the straight length at the crossing is provided.
2. So in this method, one end oft,1e curve is tangential to the tongue rail and springs up from the heel of the switch and the other end springs up from the toe of crossing and is tangential to the straight length of the crossing.
3. With the *use* of this method, out of the three kinks, two kinks, namely, a kink at the toe of crossing and another kink at heel of switch is removed. Only one kink, which is unavoidable by any of the improved methods, namely, a kink at the toe of switch is left.

Design Calculations of Method III: Let the straight length of arm at crossing be $x = T'C$ (as shown in Fig. 2.22.3).



Fil. I.JU. Design of turnout'.

1. **Radius, R:** Now, with the given values of G, *D*, a, P and *x*, the turnout is designed as follows :

From /!*TPT'*

$$\text{Sin } \angle PT'T = \frac{TP}{TT'}$$

$$TT' = TP \text{ cosec } \angle PT'T = Tf \text{ cosec } \frac{a+P}{2}$$

$TF = T'F \quad 1 \quad 1 \quad a+P$

...(2.22.11)

$= -_2\ TT' = -_2\ TP\ cosec\ -_2-$

Also from $\Delta OFT'$, where O is the centre of the curve.

$$\sin\angle T'OF = \frac{T'F}{OT'} = \frac{T'F}{R_0}$$

$$R_0 = \frac{T'F}{\sin\angle T'OF} = \frac{T'F}{\sin\alpha - \beta} = T'F \operatorname{cosec} \frac{\alpha - \beta}{2}$$

$$R_0 = \frac{1}{2} TP \operatorname{cosec}\frac{\alpha+\beta}{2}\operatorname{cosec}\frac{\alpha-\beta}{2}$$

[Putting $T'F$ from eq. (2.22.11))

$$= \frac{TP}{2\sin\frac{\alpha+\beta}{2}\cdot\sin\frac{\alpha-\beta}{2}} = \frac{TP}{\cos\beta - \cos\alpha}$$

$$= \frac{G'}{\cos\beta - \cos\alpha} \quad [\text{as } TP = G'] \qquad \text{...(2.22.12)}$$

where, $G' = TP = TS - PS = TL - T'N$

$$= G - d - x\sin\alpha \qquad (\because TS = G - d)$$

$$R_0 = \frac{G - d - x\sin\alpha}{\cos\beta - \cos\alpha} \qquad \text{...(2.22.13)}$$

$$R = R_0 - \frac{G}{2} \qquad \text{...(2.22.14)}$$

2. Crossing Lead (L):

$$L = CN + NS = ON + T'P$$

$$= x\cos\alpha + TP\cot\frac{\alpha+\beta}{2}$$

$$L = x\cos\alpha + G'\cot\frac{\alpha+\beta}{2}$$

$$= x\cos\alpha + (G - d - x\sin\alpha)\cot\frac{\alpha+\beta}{2} \qquad \text{...(2.22.15)}$$

$$d = G - \frac{L - x\cos\alpha}{\cot\frac{(\alpha+\beta)}{2}} - x\sin\alpha \qquad \text{...(2.22.16)}$$

Que 23. alculate all the elements required to set oui a 1 in 12 **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 face of the outer main rail and passes through TNC, given the hell** divergence as 11.4 cm **(AKTU 2017-18, 10 Marks)**

Answer

Given: Gauge, $G = 1.676$ m, Heel divergence, $d = 11.4$ cm 7 0.114 m, Number of crossing, $N = 12$

To Find : All the elements of turnout.

1. From right -angle method

$$\cot a = N = 12$$

$$a = \cot^{-1} 12$$

$$\alpha = 4° 45' 49''$$

2. Curve lead is given by, CL= $G \cot f$ = 1.676 x cot $\frac{4^0 4}{} \frac{'49''}{}$ = 40.29 m

3. $$Ro = \frac{CL}{\sin a} = \frac{40.29}{\sin 4°45'49} = 485.15\text{m}$$

4. 2

5. Switch load is given by, $SL = \sqrt{2Rd} = \sqrt{2 \times 485.15 \times 0.114} = 10.51$ m

6. Crossing Lead is given by, L,

$$= CL - SL = (40.29 - 10.51) \text{ m} = 29.78 \text{ m}$$

7. Therefore, with overall length of the curve, *i.e.*, 40.29 m and the radius 'R_0' = 485.15 m, the curve can be set by off-set method, starting from the given tangent point.

Que 24. Explain the different points and crossings with the help of neat sketches used in railways.

Answer

A. Points : The points or switches are of two types :

1. Stud Switch :

i. In a stud switch no separate rails are provided and some portion of the track is moved from one side to the other side.

ii. Stud switches are no more in use in Indian Railway.

iii. They have been replaced by split switches.

2. Split Switch :

i. These consist of a pair of stock rails and a pair of tongue rails.

11.. Split switches may also be of two types-loose heel type and fixed heel type.

Loose Heel Type :

a. In this type of split switch, the switch or tongue rail finishes at the heel of the switch to enable movement of the free end of the tongue rail.

b. The fish plates holding the tongue rail may be straight or slightly bent.

c. The tongue rail is fastened to the stock rail with the help of a fishing fit block and four bolts.

d. All the fish bolts in the lead rail are tightened while those in the tongue rail are kept loose or snug to allow free movement of the tongue.

Fixed Heel Type :

a. In this type of split switch, the tongue rail does not end at the heel of the switch, but extends further, and is rigidly connected.

b. The movement at the toe of the switch is made possible on account of the flexibility of the tongue rail.

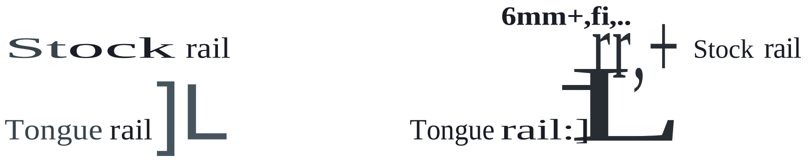
3. Depending upon the shapes, the switches can be classified as follows :

i. **Undercut Switch** :

  a. In this type of switch, the tongue rail at the toe of the switch is planed to a very fine edge at the top and cut so that the toe is accommodated under the head of the stock rail.

  b. The head of the stock rail is straight or slightly planed.

  c. Also the foot of the stock rail should be properly cut away to accommodate the foot of the tongue rail.



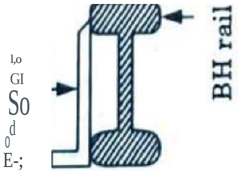
(a) Old undercut switch (b) Modified undercut switch

4. Fig. 2.%4.1.

ii. **Straight** Cut **Switch** :

  a. This type of switch is known as the straight cut switch because the tongue rail is kept straight in line with the stock rail as shown in Fig. 2.24.2.

  b. Thus the thickness of the toe of tongue rail becomes thick and thereby its strength is increased.



Straight cut switch

Fig. 2.M.2.

  c. For this type of switch, the stock rail is joggled by an amount equal to the thickness of the tongue at 13 mm from the toe.

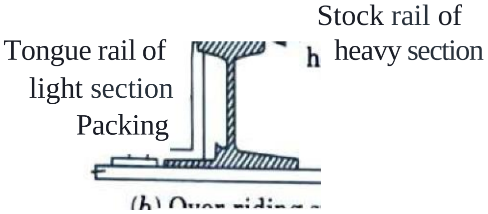
iii. **Over-riding Switch or Composite Switch** :

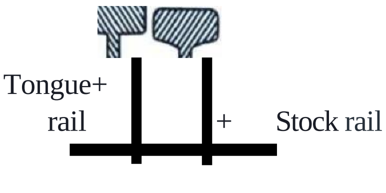
  a. In this type of switch, separate rail sections are adopted for stock rail and tongue rail.

  b. The _stock rail is of heavy section while the tongue rail is oflight section.

  c. The tongue rail rides over the foot of stock rail as shown in Fig. 2.24.3(a).

  d. This design of swit h will not be useful in loose-heel type of switch because different fish-plates will be used and this will result in further weakening of the joint.





(b) Over-riding switch (a) Modified over-riding switch

Fig. 2.24.3,

B. Crossings :

1. When one rail crosses another rail, a crossing occurs.
2. Thus it is a device which is provided at the intersection of two rails so as to permit the vehicles moving along one of the track to pass across the other track.

Type of Crossing : Following are the two types of crossings :

1. Ordinary or Acute Crossing :

i. Fig. 2.24.4 shows a typical ordinary or acute built-up crossing.

ii. All the measurements are taken from the theoretical nose of crossing.

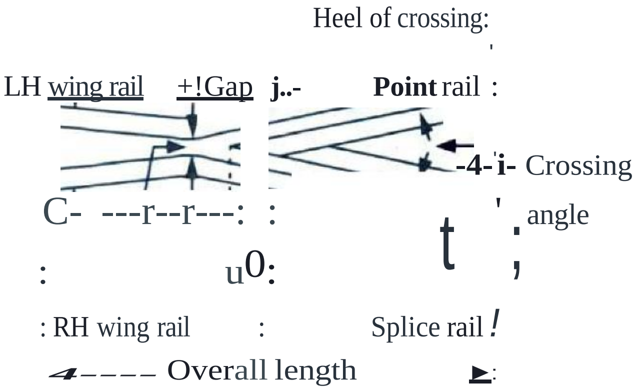


Fig. 2.24.4. Ordinary or acute crossing.

2. Double or Obtuse Crossing :

i. A double crossing has two noses and is used in the fonnation of diamonds.

ii. The gauge lines intersect at elbow as shown in Fig.2.24.4 and all measurements for locating the crossing are to be taken from elbow.

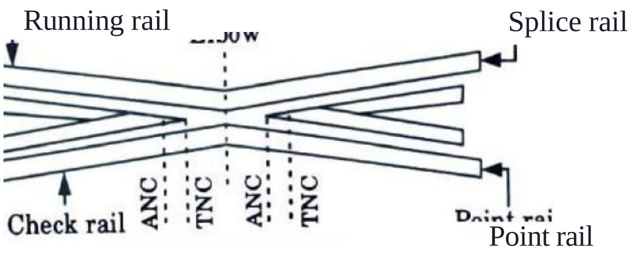


Fig. 2.24.5. Double crossing.

iii. The diamond crossings may be situated on straight track or curved track.

iv. They may occur between similar tracks or unsimilar tracks.

v. When the angle becomes 90°, it is known as the square crossing as shown in Fig. 2.24.5 and it should be avoided as far as possible because there is rapid wear of the crossings and damage to the rolling stock on account of the heavy impact.

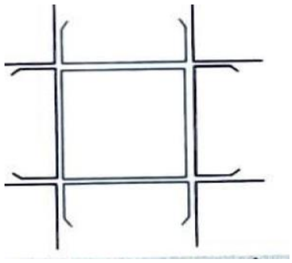


Fig. 1.24.8. Square crossing

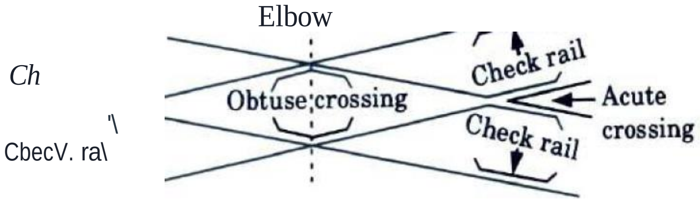


Fig. 2.24.7. Diamond crossing.

Que 26. Illustrate with neat sketches various types of track junctions adopted by Indian Railways. State their merits and the context in **which each type is adopted.** . .

Answer

Types of Track Junctions: Following are the types of track junctions :

1. **Turnouts:** This is simplest combination of points and crossings. The salient features are :

i. To provide facilities for turning of trains from one track to another.

ii. One turnout provides facilities for turning of vehicles or trains in one direction of the main track only.

iii. 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.

2. **Symmetrical Split or Equivalent Turnout:**

i. When a turnout is taken off from a curved track, it is termed as a split.

ii. When a straight track is split up in two different directions (contrary flexture) with equal radii, it is known as a symmetrical split.

iii. For such cases, the number of crossings 1 in 6 is generally used.

iv. It consists of a pair of points, 4-curved lead rails, 2 check rails and one acute angle crossing.

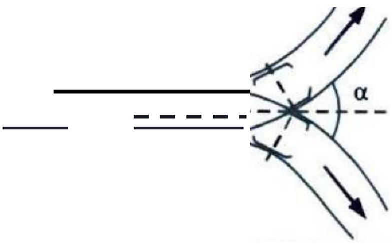
v. The salient features of this track-junction are:

a. The radii of the main track curve and the lead curve are equal.

b. The turnout is symmetrical about the centre line.

c. This provides the facilities for turning of trains in both left and right directions of the main track.

vi. It is suitable for locations where turnout from a straight track would take too much of space.



Fiar. 2.26.1. Symmetrical slip.

3. Three Throw Switches (Contrary and Similar Flextures) :

i. When the turnout from a curved track turns away in the opposite direction, the curves are said to be in contrary flexture

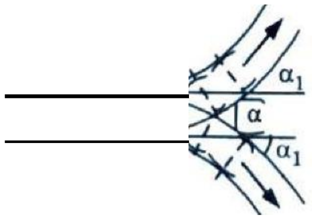
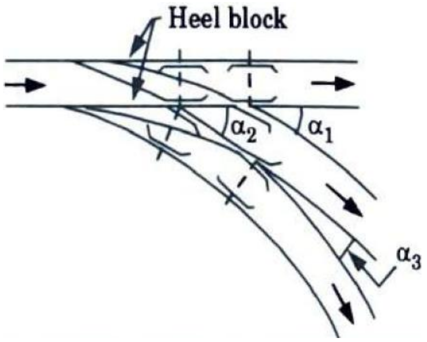


Fig. l.iG.2. Three Throw Switch (Contrary flexture)



Fi1. 2.25.3. Three Throw Switch (Similar flexture).

ii. If the turnout and the main track turn in the same direction, the curves are said to be in similar flexture.

iii. When two turnouts take off from the same point of a main straight track, it is called "Three•throw" arrangement.

iv. If the turnouts are on either side of the main track, this arrangement is termed as three throw switch with contrary flexture.

v. If these turnouts are on one side of the main track the arrangement is termed as three throw switch with similar flexture (being on same side).

vi. The salient features of three throw switch are :

   a. It consists mainly of two switches (each switch has two tongue rails lying side by side), combined heel blocks for both the tongue rails of the switch, two stock rails, three crossings and check rails (4 for contrary flexture and 6 for similar flexture).

   b. It is unsuitable for main lines with heavy traffic, because use of double switches may lead to derailments.

   c. In case of three throws of contrary flexture, the radii of turnouts are same but for the similar flexture the radii are different and moreover the curves have to start at different points from main curve.

vii. This may be used in congested areas where space is not enough and heavy traffic is not prevailing such as goods yards, entrances to locomotive yards, etc.

4. Double Turnout or Tandem or Following Point Crossing :

i. This arrangement is an improvement or modification over a three-throw switch.

ii. This eliminates the defects of three-throw switch because heels of the two switches do not overlap as they are kept at a certain distance from each other.

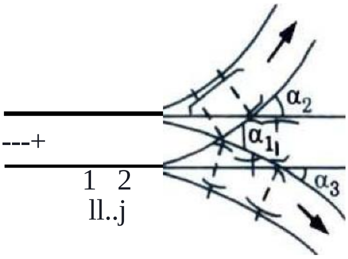


Fig. 1.21.4. Double Turnout (or Tandem);

iii. The salient features of this track junction are :

a. Two turnouts take off from the main track at two different point (Fig. 2.25.4, points 1 and 2 are marked).

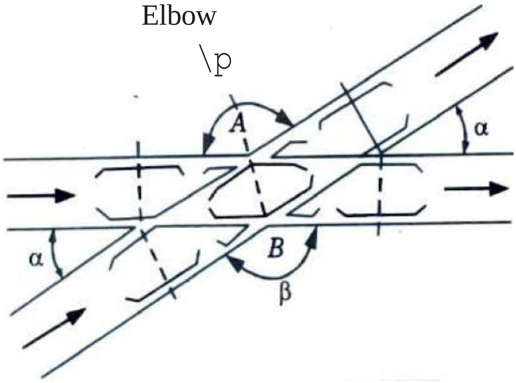
b. In Fig. 2.25.4, the crossings angles'½ and u_3 may be equal but crossing angle al' has to be of different angle depending upon the set-back (x) the two sets of points.

c. They may be of similar flexture or contrary flexture.

iv. They 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.

5. **Diamond Crossing** :

i. 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 as diamond crossing.



Fit, 2.25.5. Diamond crossing.

ii. The salient features of this crossing are as follows :

a. It consists of two acute-angle crossings (a and a), two obtuse angle crossings (p and p) and four check rails.

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

c. Indian standards specify the limit of flattest diamond to be 1 in 10 for BG and 1 in $8\frac{1}{2}$ for other gauges.

d. Diamond crossings should be avoided as far as possible on curves as they necessit.ate restriction on speed

Que 26. **What are the different types of station yards ? Explain the working of any one with the help of neat sketches. (AKTU 2016-17,**

10 Marks)

OR

Define the different types of yards and explain their functions with neat sketches.

OR

Write a note on:

i. Marshalling yards, and
ii. Locomotive yards.

OR

Illustrate with neat sketches the function and working principle of marshalling yard.

Answer

A. **Yards**:

1. A yard is a system of tracks laid out to deal with the passenger as well as goods traffic being handled by the railways.
2. This includes receipt and dispatch of trains apart from stabling, sorting, marshalling, and other such functions.

B. **Types**: Yards are normally classified into the following categories:

1. Coaching Yard :

i. The main function of a coaching yard is to deal with the reception and dispatch of passenger trains.
ii. Depending upon the volume of traffic, a yard provides facilities, such as watering and fuelling of engines, washing of rakes, examination of coaches, charging of batteries, and transshipment of passengers.

2. Goods Yard:

i. A goods yard provides facilities for the reception, stabling, loading, unloading, and dispatch of goods wagons.

ii. Most goods yards deal with a full train load of wagons.

iii. No sorting, marshalling, and reforming is done at goods yards except in the case of sick wagons or a few wagons booked for that particular station.

3. Locomotive Yard:

i. The locomotive yard houses the locomotives.

ii. Facilities for watering, fuelling, examining locomotives, repairing, etc., are provided in this yard.

iii. The yard layout is designed depending upon the number oflocomotives required to be housed in the locomotive shed.

iv. The facilities are so arranged that a requisite number oflocomotives are serviced simultaneously and are readily available for hauling the trains.

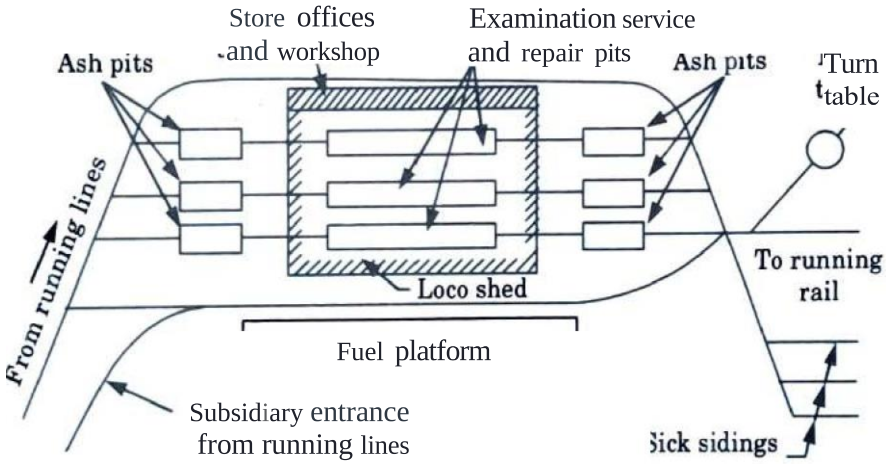


Fig. 2.26.1. Locoyard and Shed.

4. Sick Line Yard

i. Whenever a wagon or coach becomes defective, it is marked sick and taken to sick lines.

ii. The sick line yard deals with such sick wagons.

iii. Adequate facilities are provided for the repair of coaches and wagons, which include examination pits, crane arrangements, and train examiner's office and workshop.

iv. A good stock of spare parts should also be available with the TXR (train examiner) for repairing defective rolling stock.

5. Marshalling Yard :

i. The marshalling yard is the yard where goods trains are received and sorted out and new trains are formed and finally dispatched to various destinations.

ii. It receives loaded as well *as* empty goods wagons from different stations for further booking to different destinations.

iii. These wagons are separated, sorted out, properly marshalled, and finally dispatched bearing full trainloads to various destinations.

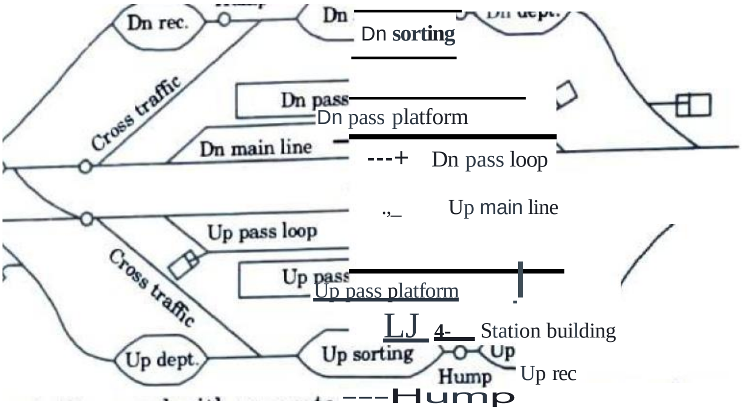
iv. The marshalling of trains is so done that the wagons can be conveniently detached without much shunting en route at wayside stations.

v. **Functions** : Following are the functions of marshalling yard :

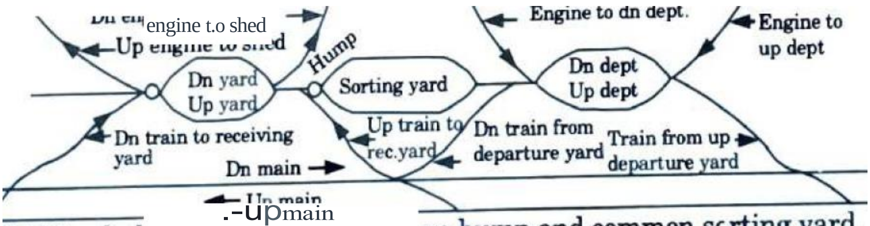
a. Reception of Trains: Trains are received in the reception yards with the help of various lines.

b. Sorting of Trains : Trains are normally sorted with the help of a hump with a shunting neck and sorting sidings.

c. Departure of Trains: Trains depart from departure yards where various lines are provided for this purpose. Separate yards may be provided to deal with upand down traffic as well as through trains, which need not to be sorted out.



(a) Marshalling yard with separate humps and separate sorting lines.



(b) Marshalling yard with a common hump and common sc.rting yard

Fig. 2.26.2. Layout of marshalling yards.

C. Principles of Design :

i. A marshalling yard should be so designed that there is minimum detention of wagons in the yard and as such sorting can be done as quickly as possible.

ii. These yar s should be provided with the necessary facilities, such as a long shuntmg neck, roperly designed hump, bralting arrangement in the shape ofmecharucal retarders, etc., depending upon the volume of traffic.

iii. The following points should be kept in mind when designing a marshalling yard:

a. Through traffic should be received and dispatched as expeditiously as possible. Any idle time should be avoided.

b. There should be a unidirectional movement of the wagons as far as possible.

c. There should be no conflicting movement of wagons and engines in the various parts of the yard.

d The leads that permit the movement of wagons and train engines should be kept as short as possible.

e. The marshalling yard should be well lighted.

f. There shoula be adequate scope for further expansion of the marshalling yard.

D. Types of Marshalling Yard : Following are the types of marshalling yard:

1. Flat Yard:

i. In this type of yard, all the tracks are laid almost level and the wagons are relocated for sorting, etc., with the help of an engine.

ii. This method is costly as it involves frequent shunting, which requires the constant use oflocomotive power.

iii. The time required is also more as the engine has to traverse the same distance twice, first to carry the wagons to the place where they are to be sorted and then to return idle to the yard.

iv. Flat yard is adopted when :

a. There is limitation of space.

b. There is a severe limitation of funds.

c. The number of wagons dealt with by the marshalling yard is very low.

2. Gravitation Yard:

i. In this yard, the level of the natural ground issuch that it is possible to lay some tracks at a gradient.

ii. The tracks are so laid that the wagons move to the siding assigned for the purpose of sorting by the action of gravity.

iii. Sometimes, shunting is done with the help of gravity assisted by engine **power.**

iv. However, it is very seldom that natural ground levels are so well suited for gravitation yards.

3. **Hump Yard** :

i. In this yard, an artificial hump is created by means of proper earthwork.

ii. The wagons are pushed up to the summit of the hump with the help of an engine from where they slide down and reach the sidings under the effect of gravity.

iii. A hump yard, therefore, can be said to be a gravitation yard as shunting is done under the effect of gravity.

iv. The topography of the location of the yard also plays an important role in deciding the gradient.

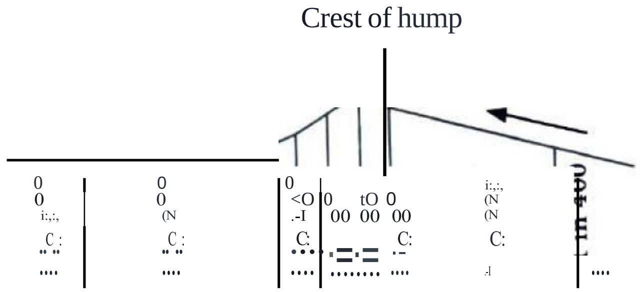


Fig. 2.26.3. Hump yard Gradients.

Que 27. Describe the factors that influence the selection of site for a railway station.

Answer

The following factors should be considered while selecting a site for a railway station :

1. **Adequate Land** :

i. There should be adequate land available for the station building, not only for the proposed line but also for any future expansion.

ii. The proposed area should also be without any religious buildings.

2. **Level Area with Good Drainage** :

i. The proposed site should preferably be on a fairly level ground with good drainage arrangements.

ii. It should be possible to provide the maximum permissible gradient in the yard.

iii. In India, the maximum permissible gradient adopted is 1 in 400, but a gradient of 1 in 1000 is desirable.

3. **Easy Accessibility** : The station site should be easily accessible. The site should be near villages and towns.

4. **Alignment** :

i. The station site should preferably have a straight alignment so that the various signals are clearly visible.

ii. The proximity of the station site to a curve presents a number of operational problems.

5. **Water Supply Arrangement :** While selecting the site it should be verified that adequate water supply is available for passengers and operational needs.

Que 28. Discuss the classification of stations based on

functioning.

Answer

Classification : Functional classifications of stations are as follows :

1. **Halt:**

   i. A halt is the simplest station where trains can stop on a railway line.

   ii. A halt usually has only a rail level platform with a name board at either end.

   iii. Sometimes a small waiting shed is also provided which also serves as a booking office.

   iv. There is no yard or station building or staff provided for such types of stations.

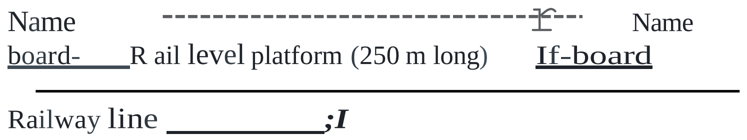


Fig. 2.28.1. Layout of a .halt station.

2. **Flag Station** :

   i. A flag station is more important as a stopover for trains than a halt and is provided with a station building and staff.

   ii. On controlled sections, a flag station is equipped with either a Morse telegraph or a control phone, which is connected to one of the stations on either side to facilitate easy communication.

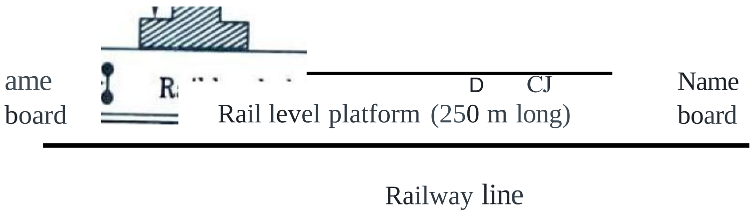


Fig. 2.28.2. Layout of a flag station.

   iii. A flag station is usually provided with a small waiting alld booking office, platforms and benches and arrangements for drmkmgwater.

   iv. Sometimes a flagstatioo is also provided with asiding for stablingw agons booked for that station.

3. **Wayside or Crossing Station** :

   i. The wayside or crossing station comes after a flag station.

   ii. While a flag station has arrangements for dealing with traffic but none for controlling the movement of the trains, a crossing station has arrangements for controlling the movement of trains on block stations.

   iii. Crossing stations may be classified into (a) roadside small and medium sized stations, and (b) major stations.

a. **Wayside or Crossing Station on a Single Line Section** : Increasing traffic on a single line section necessitates the construction of a three line station, which provides an additional line as well as more facilities for passing traffic.

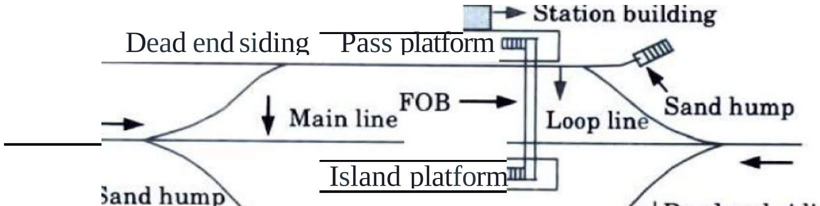


Fig. 2.28.3. A wayside or crossing station on a single line section.

b. Double Line Crossing Station with an Extra Loop :

In the case of a double line section, which consists of separate up and down line to deal with traffic moving in either direction, the layout of a station yard is somewhat different.

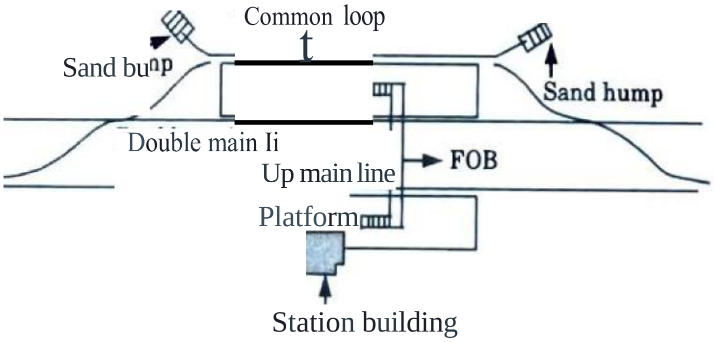


Fig. 2.28.4. Double line crossing station with three lines.

c. Double Line Crossing Station with Four Lines : The common layout of a station yard on a double line section has fow- line station as shown in Fig. 2.28.5.

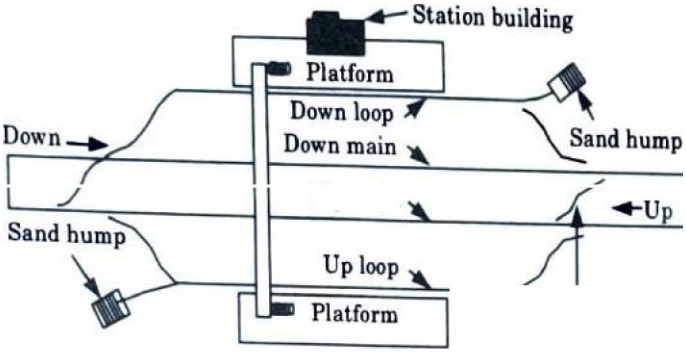


Fig. 2.28.5. Double-line crossing station with four lines.

4. Junction Station :

i. A junction station is the meeting point of three or more lines emerging from different directions.

ii. Normally at junction, trains arrive on branch lines and return to the same station.from where they started or proceed to other stations from where they again return to their originating stations.

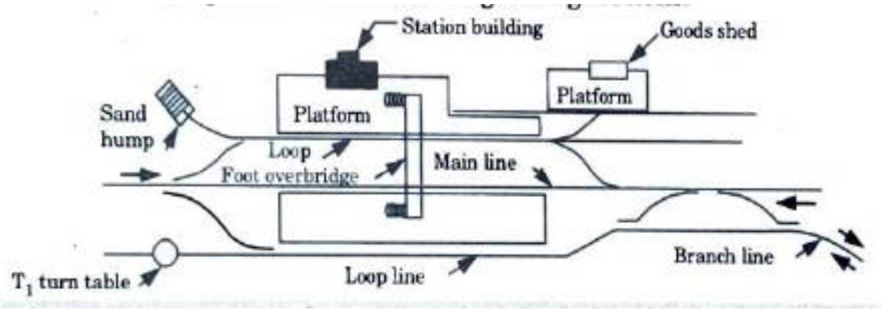


Fig. 2.28.6. Junction station with single ma line and singla. branch line.

5. **Terminal Station** : The station at which a railway line or one of its branches terminates is known as a terminal station or a terminal junction.

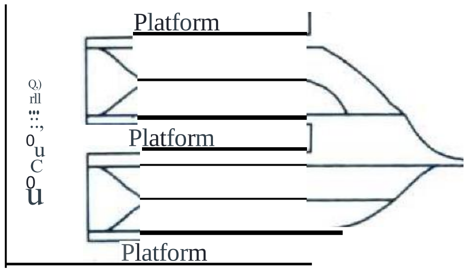


Fig. 2.28.7. Terminal station with run round line.