DATE
PAGE NO.

ADVANTAGES OF RAILWAYS

Railways have brought about many political, social and economic changes in the life of Indian people:

(a) Political Advantages

(i) Railways have united the people of different castes, religious customs and traditions.

(ii) With the adequate network of railways, the central administration has become more easy and effective.

(iii) Railways have contributed towards development of a national mentality in the minds of people.

(iv) The role of railways during emergencies in mobilising troops and war equipment has been very significant.

(v) Railways have helped in the mass migration of the population.

(b) Social Advantages

(i) The feeling of isolation has been removed from the inhabitans of the Indian villages.

(ii) By travelling together into the compartment without any restriction of caste, the feelings of caste difference has disappeared considerably.

(iii) The social outlook of the masses has been broadened through railway journeys.

(iv) Railway has made it easier to reach places of religious importance.

(v) Railways provide a convenient and safe mode of transport the country.

(c) Economic Advantages

(i) Mobility of people increased, thereby the congested

DATE
PAGE NO

areas can be relieved of congestion and the sparse populated areas can be developed.

(ii) Mobility of labour has contributed to industrial development.

(iii) During famines, railways have played the vital role in transporting food and clothing to the affected areas.

(iv) Growth of industries has been promoted due to transportation of raw materials through railways.

(v) Speedy distribution of finished product is achieved through railways.

(vi) Railways provide employment to millions of people and thus help in solving the unemployment problems of the country.

(vii) Trade development due to railways thereby has increased the earnings and standard of living of Indian people.

(viii) Land values have increased due to industrial development which ultimately result in the increase of national wealth.

(ix) Due to the mobility of products through railways, the price stabilisation of commodities could be possible.

(x) Commercial farming is every much helped by the railway network throughout the country.

(d) Techno-Economic Advantages

(i) Cost saving in transportation of long haul bulk traffic.

(ii) Energy-Efficiency (railways consume one-seventh of fuel used by the road sector).

(iii) Environment friendliness.

(iv) Higher safety (fatal accidents one-tenth of road

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DATE	
PAGE NO.	

sector in India).

(v) Efficient Land use and ease in capacity expansion

CLASSIFICATION OF INDIAN RAILWAYS

Railway Board has classified the Indian Railway lines on the basis of the importance of route, Traffic carried and maximum permissible speed on the routes, into the following 3 main categories:

(1) Trunk Routes
(2) Main Lines.
(3) Branch Lines.

Railway Board has given the following specifications for these lines.

(1) Trunk Routs ⟶ The following 6 routes of B.G. and 3 routes of M.G have been classified as trunk routes:

On B.G. 1. Delhi – Mughalsarai – Howrah. 2. Delhi – Kota – Mumbai. 3. Delhi – Jhansi – Nagpur – Chennai 4. Howrah – Bagpur – Mumbai 5. Mumbai – Guntakul – Chennai. 6. Howrah – Vijyawada – Chennai.

On M.G. 1. Lucknow – Gorakhpur – Guwahati. 2. Delhi – Jaipur – Ahmedabad 3. Chennai – Madurai – Trivandrum.

The following track standards for trunk routes have been specified.

	ITEMS	BG	M.G
1	Maxim. Permissible speed	120 km.ph	80 km ph.
2	Rail section	52 kg/m or heavier	37.2 kg/m (i.e 75R)
3	Sleeper density	(n+7)	(n+7)

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4	Ballast Cushion	25cm below sleeper	25cm below sleeper
5	Degree of curvature	7½	Suitable degree
6	Design speed for new track	160 kmph	100 Km p.h.

(2) Main Lines → All lines other than trunk routes carrying 10 Gross Million Tonnes (G.M.T) per annum or for B.G. and 2.5 G.M.T. or more for M.G. or where maximum permissible speed allowed is 100 km.p.h for B.G. and 75 km.p.h for M.G. are classified as main lines.

The following specifications have been laid down for main lines by Railway Board:

	ITEMS	B.G.	M.G.
1	GMT/ Annum	≥ 10	≥ 2.5
2	Maxm. permissible speed	100 km.p.h	75 km.p.h
3	Track relaying period	20 years	30 years
4	Rail section	52kg/m	37.2 kg/m (or 75R)
5	Design speed for new track	120 km.p.h	75 km.p.h

(3) ~~Main~~ Branch Lines ⟶ These are classified on the basis of following criteria: All those B.G. lines which carry less than 10 Gross Million Tonnes (G.M.T) per annum and have maximum permissible speed of less than 100 km p.h are classified as Branch Lines.

The track specifications would vary depending upon the requirements of traffic subject to the following conditions:

(i) B.G. locomotive (WG/WP type) and Box wagons would be allowed to operate over all branch lines at a reasonable speed.

(ii) M.G. engines (YG/YP) type and wagons with a maximum axle load of 12 tones would be permitted to operate on all branch lines at a reasonable speed.

(iii) No new rails will normally be used on branch lines.

CHAPTER-1

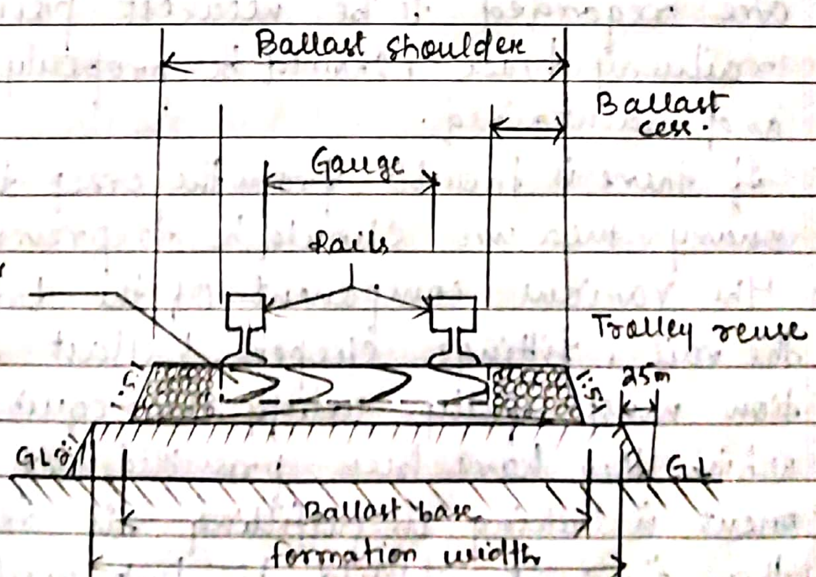
14/01/2020

RAILWAY TRACK
(Permanent Way)

Permanent Way: The combination of rail, fitted on sleeper and resting on ballast and subgrade is called railway track or permanent way.

→ Sometime temporary track are also laid for conveyance of earth and material during construction work.

→ The name permanent way is given to distinguish the final layout of track from these temporary tracks.



Typical Cross-section of a Permanent Way on Embankment

DATE

PAGE NO.

REQUIREMENTS OF AN IDEAL PERMANENT WAY

- ★ The guage should be correct and uniform.
- ★ The rail should be in proper level. In a straight track, two rail 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.
- ★ Alignment should be correct.
- ★ The gradiant should be uniform and as gentle as possible. Any change of gradient should be followed by a smooth vertical curves, to give smooth riding quality.
- ★ The track should have enough lateral strength
- ★ The radii and superelevation on curves should be properly designed and maintain.
- ★ Drainage system must be perfect for enhancing safety and durability of track.
- ★ Joint, including point and crossing which are regarded to be weakest points of the railway track, should be properly designed and maintained.
- ★ If there is trouble from the creep the preventionary measures should be to prevent it.
- ★ The various component of the track that is the rail, fittings, sleepers, ballast and formation must fully satisfy the requirements for which they have been provided. If any component is lacking in fulfilling its requirement then there it should be improved or replace
- ★ There should be adequate provision for easy renewable and replacements.

DATE
PAGE NO

* The track structure should be strong, low in intial cost as well as maintaince cost.

GAUGE IN RAILWAY TRACK

The gauge of a railway track is define as a clear distance between inner or running face of two track rail. The distance between the inner face of a pair of wheel is called the 'wheel gauge'.

TYPES OF GAUGE

Gauge is of 3 types

Types of Gauge	Gauge width
(i) Standard gauge (B.G.)	1.67m
(ii) Metre gauge (M.G)	1m
(iii) Narrow gauge (N.G)	0.762m.

RAILS

* The rail on the track can be consider as steel girder for the purpose of carring axial load.

* They are made up of high carbon steel to withstand wear and tear.

* Flat-footed rail are mostly used in railway track.

FUNCTION OF RAIL

* Rail provide a hard, smooth and unchanging surface for passage of heavy moving load with a minimum friction between the steel rails and steel wheel.

DATE
PAGE NO

* Rail bear the stress develop due to heavy vertical load, lateral and breaking forces and thermal stresses.

* The rail material used in such that it gives minimum wear to avoid replacement charges and failure of rail due to wear.

* Rail transmit the load to sleeper and consiquintly reduced the ~~CONSTGE~~ pressure on ballaste and formation below.

COMPOSITION OF RAIL STEEL

REQUIREMENT OF RAIL

* They should be proper composition of steel and should be manufacture by duplex process.
* The vertical stiffness should be high enough to transmit the load to several sleeper underneath. The height of the rail should be adiquate.
* The head must be sufficiently deep to allow for an adiquate margin of the vertical wire. The wearing surface should be hard.

* The bottom of the head and top of the foot of rail should be so shaped as to enable to the fish plate to transmit the vertical load efficiently from the web to the foot & rail joint.

* Relative distribution of material of rail in hea

and top of the foot of rail must be balanced, for smooth transmission of loads.

* The centre of gravity of the rail in section must lie approximately at mid-height so that maximum tensile and compressive stresses are equal.

* The fillet radii must be large to reduce the concentration of stresses.

TYPES OF RAIL SECTION

The three types of ~~soil~~ rail section which have been found so far the construction of railway track are:

1) Double headed rails (D.H Rails)
2) Bull headed rails (B.H Rails)
3) Flat footed rails (F.F rails)

Comparison of Rail types -

Sl. No	Point of Comparison	Flat footed Rails	Bull-headed rails and double headed rails.
1.	Strength and stiffness	These have more strength and stiffness for the same weight both laterally and vertically.	These have less strength and stiffness.
2.	Laying and relaying	Fitting of these rails is simpler and so can be easily laid and related to chairs and required.	The fitting of these rails is difficult.

3.	Arrangements at points, crossings and at sharp curves.	The arrangements are simpler and easy.	The arrangements are complicated and difficult.
4.	Initial cost	These rails require layer and cheaper fastenings so the initial cost is less.	Initial cost is more and costly.
5.	Rigidity	They are more rigid	They are less rigid
6.	Maintenance cost	The maintanance cost is less.	It requires heavy maintenance cost.
7.	Suitability	These are more suitable due to better stability economy, strength and stiffness.	These are more suitable when lateral loads are more important rather than vertical loads.

FLAT FOTTED RAILS

Merits – (i) They have more strength and stiffness both vertically laterally, than B.H Rails.

(ii) Fitting of rails with sleepers is simpler, so they can be easily laid and relaid.

(iii) No chairs or keys are required as in case of B.H Rails.

(iv) The points and crossings, the arrangements are

DATE
PAGE NO.

simpler than B.H Rails.

Demerits - The fittings get loosened more frequently than in case of B.H Rails.

→ Bull headed Rails (B.H)
Merits - The rails are easily disconnected from sleepers as they have no direct connection with the latter.

Demerits - (i) They require additional cost of iron chairs.
(ii) They have less strength and stiffness.
(iii) They requires heavy maintenance cost.

RAIL FAILURE
(1) Crushed Head - Crushed heads are those which have either sagged or flattened. Besides the defect of manufacture, crushed heads are due to (a) slipping of wheels. (b) Flat spots on wheels which are development due to skidding of wheels, (c) weak support at the rail end. This weak end support may be due to loose fish bolts

(2) Square or angular break - The rail may be completely broken either in a vertical plane or in an inclined plane.

(3) Split Heads - In, this cracks occur in the surface of the cracks, when are split from the side to the end of the heads, when opened appears smooth and dark, the defective rail is known as "piped rail".

DATE

PAGE NO

(4) Split web - This is the through crack in the web, through not necessarily, runs through the bolt holes.

(5) Horizontal fissures - These are developed in the rail head. They are more in the form of a fracture and develop gradually.

(6) Transverse fissures - This is the most common cause of rail failures in America. It is a cross wire crack which starts from a point inside the head and spreads like contour shape gradually. The broken surface has a smooth oval or round bright spot. This defect is either a manufacturing defect or may occur due to overstraining of metal in service.

27/01/20

DATE
PAGE NO.

SLEEPERS

Defination: Sleepers are member generally laid traverce to the rails on which the rails are supported and fixed, to transfer the loads from to the ballast and subgrade below.

Functions of sleepers:

(i) To hold the rails to correct gauge.
(ii) To hold the rails in proper level.
(iii) To act an elastic medium, in between the ballast & rail to absorb the blows and vibration of moving load.
(iv) Sleeper as also added to the longitudinal and lateral stability of the permanent track on the whole.
(v) They also provide means to rectify track geometry during service life.

Requirements of sleepers:

(i) The sleeper to be used should be economical, that is they have minimum possible initial and maintenance cost.

(ii) The fittings of the sleeper should be such that they can be easily adjusted during maintanance operation such as easy lifting, packing, removal and replacement.

(iii) The weight of the sleeper should not be too heavy or excessively light. That is should have moderate weight for easy of handling.

(iv) The design of sleeper should be such that they are not damaged during packing processes.

DATE

PAGE NO

(v) The design of sleeper should be such that there are not pushed out easily due to moving trains especially with steel sleepers with rounded ends.

Classification of sleepers

Sleeper can be classified into three types:

(i) Wooden sleeper
(ii) Metal sleeper - (1) Cast iron (2) steel sleeper
(iii) Concrete sleeper - (1) Reinforce concrete sleeper
(2) Prestressed concrete sleeper.

TIMBER OR WOODEN SLEEPERS

Advantage - (i) Timber is easily available in all part of India.
(ii) Fittings for wooden sleeper are few and simple in design.
(iii) These sleepers are able to resist the shocks and vibration due to heavy moving loads and also gives less noisy track.
(iv) Wooden sleeper are easy to lay, relay pack and maintain.
(v) These wooden sleeper are suitable for all types of ballast.

Disadvantage - (i) The sleeper are subjected to wear, decay, attack by white ants, spike killing, warping, cracking rail cutting etc.
(ii) It is difficult to maintain the gauge in case of wooden sleeper.
(iii) Track is easily disturbed, that is alingment maintenance is difficult.
(iv) Wooden sleeper have get minimum survice life (12 to 15 year) as compared to other type of sleeper.

DATE
PAGE NO.

(v) Maintenance cost of wooden sleeper is highest as compared to other sleepers.

METAL SLEEPERS

Advantage - (1) Metal sleeper can uniform in strength and durability.
(2) They should bear the tensile and compressive stress which come on to them.
(3) In metal sleeper the performance of fitting is better hence less on creeps occurs.
(4) Metal sleeper are economical, as life is longer & maintanance is easier.
(5) Gauge can be easily adjusted and maintain in case of metal sleeper.
(6) The metal sleeper frequent renewal is not required

Disadvantage - (1) More ballast is required than other type of sleeper.
(2) Fittings required are greater than in no. of and difference to maintain and inspection.
(3) Metal, cast iron or steel these are liable to rusting corrosion.
(4) Metal being and good conductor of electricity interferee with track circuiting.

STEEL SLEEPERS

Advantage - (1) The sleepers should maintain perfect gauge.
(2) The rail should have a sufficient heavy ~~bearing~~ ~~and~~ for stability. bearing area of the sleepers.
(3) They should be sufficient heavy for stability.
(4) Steel sleeper these are casting in one piece.
(5) The gauge, by use of steel sleeper can be easily adjusted and maintain.

DATE
PAGE NO

⑥ The manufacturing of sleepers can be done by a simple process.
⑦ The life of sleepers is much more than that of wooden sleeper.

Disadvantage - ① In steel sleeper generally crack at rail seat.
ⓘⓘ The sleeper, being of metal are level to corrosion
ⓘⓘⓘ The cost of steel sleepers is relatively more than the wooden sleeper.

CONCRETE SLEEPER

ⓘ They have maximum life where compare to other sleeper (40 to 60 years).
ⓘⓘ These is not affected by moisture, chemical action of ballast and subsoil salt.
ⓘⓘⓘ There is no difficulty in the track-circuiting required for electrifying the track.
ⓘⓥ The sleeper have higher elastic modulus and hence can withstand the stress induced by that and heavy traffic.

Disadvantage of concrete sleepers -
ⓘ The weight of concrete sleeper is high as 2.5 to 3 times of wooden sleeper, required the mechanical appliances for handling.
ⓘⓘ They damage the bottom edge during the packing
ⓘⓘⓘ The scrap value is almost nil.
ⓘⓥ The damage to the concrete sleeper is very heavy in case of derailment.

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DATE
PAGE NO.

Comparison of different types of sleepers —

Sl. No.	Point of Comparison	Wooden sleeper	C.I sleepers	Steel sleeper	Concrete sleeper
1.	Cost per sleeper	low	medium	high	depends upon design
2.	Life	10 to 15 years for untreated sleeper 20 to 25 years for treated sleeper.	35 to 50 years	35 to 50 years	40 to 60 years.
3.	Weight per sleeper for B.G track.	low	heavy	medium	Depends upon design but heavier than others.
4.	Maintanance cost	Higher than other sleeper	minimum	moderate	moderate
5.	Overall economy	Cheaper in the initial cost but expensive in long run.	Costlier in first cost but cheaper in long run	Same as for C.I.	Under trail.
6.	Handling	Not liable to break under rough handling.	Liable to break under rough handling.	Not liable to break, if clip and bolts are used	With improved design, not liable to break.
7.	Track fittings	Requires less fitting	Require more fitting	Require less fitting	Requires less fittings.

8.	Elasticity	Good	Not so good	Not so good	Not good
9.	Laying and Relaying	Easiest	Difficult due to large no. of fittings.	Easy due to light weight	Difficult b material/ labour. Eas it mechanic devices are used.
10.	Rigidity track	Poor both laterally and Longitudinally	Better then simple sleeper	Better then timber sleepers.	Best becau of heavy dead weigh
11.	Suitability track	Suitable for points and no stinge bridge station yard level crossing	Suitable for stone ballast unsuitable in station yards.	Suitable only for stone ballast.	Suitable fo any location on railway track.
12.	Renewal	Easy	difficult	difficult	difficult
13.	Gauge adjustment	Difficult	Easy	Easy	Easy.

Q. Find out the expression for sleeper density for a B.G. track if 19 sleeper are used under a rail length.

Ans: Length of a rail for BG track = 12.8m or 13m.

Sleeper density = $M+x$

M = Length of rail in meter

x = Factor depending upon several factor excial load, section of rail.

Sleeper density : M+x

x = 19-13 = 6

The expression for sleeper density is M+6.

7/02/20

BALLAST

Definition - Ballast is a granular material using broken stone or brick, gravel and pack bellow and around the sleeper to transmit load from sleeper.

→ It provides a suitable foundation for the sleeper and also hole the sleeper in their correct level and position, preventing their displacement by lateral or longitudinal trust.

Function of ballast

→ It transport the load from sleeper to subgrade and the distribute uniformly over a large area for formation.

→ It hole the sleeper in position and prevent the lateral and longitudinal movement. Due to dynamic load and vibration and moving train.

→ It provides easy means of maintain in the correct level of the two line of track. and for correcting the track alingment.

→ It provides good drain foundation immediately below the sleepers. and helps to protect the top surface of foundation.

Requirements of good ballast

- It should be resist the crossing under dynamic load.
- It should not make the track dirty or muddy due to powder under dynamic load but should be capable of being clean to provide good drainage.
- It should allow for easy drainage with the minimum shinkage and the void should be large enough to prevent capailary action.
- It should offer resistance to abtraction & weathering.
- It should not produced any chemical action action with rail and metal sleepers.
- The size of the stone ballast should be 5cm for wooden sleeper, 4cm for metal sleeper and 2.5cm for turn out and cross over.

DATE
PAGE NO.

GEOMETRIC DESIGN OF THE TRACK

Necessity of geometric design - Most of the train derailment there are due following reason -

1. Track defect
2. Vehicular defect
3. Operational defect

→ A train may derail under straight track due to the following defect in the track.

(i) Defected cross level
(ii) Defective alignment
(iii) Defective gauge.
(iv) Low joint

→ The derailment of the curve track may occur due to the following reason -
(i) Improper super elevation.
(ii) Improper radius of the curve.
(iii) Improper speed.
(iv) Unequal distribution of load on two rail.

→ The derailment over the turn out and crossing may occur due to the following reason -
(i) Gapping point
(ii) Lifting of toe of switch due to inadequate fitting.
(iii) Accessive wear and switches.
(iv) Tight gauge and defective check clearance at the nose of crossing.

Gradient and Grade Compensation -
- Any depratura of the track from the level is known as grade and gradient.

DATE
PAGE NO

- It is measure either by distant of rise or fall in 100 mt horizontal distance. Horizontal distance travel for a rise - or fall in 1 unity.
- Gradient on the provided on the track due to following reason.

(i) To provide uniform rate of rise or fall as far as possible.

(ii) To reduce the cost of the earthwork.

→ Types of Gradient

(i) Rulling gradient

(ii) Momentum gradient

(iii) Helper or pusher gradient

(iv) Gradient are station yard.

→ Grade compensation on curve

- In indian composition for curvature is given at 0.04% for degree of curve for B.G track. (for meter 0.03)(M.G) for 0.02 N.G).

Q. If the rulling gradient is 1 in 150 on a particular section of B.G at the same time a curve of 4° is situated on those rulling gradient, what should be allowable rulling gradient.

Ans Compensation for 4° curve → 0.04×4

$= 0.16\%$

Rulling gradient 1 in 150 $= \frac{1 \times 100}{150 \times 100} = 0.67\%$

Maximum allowable gradient or actual gradient to be provided $= 0.67 - 0.16 = 0.51\%$.

$\frac{1}{0.51 \div 100} = 196 = 1$ in 196 Ans.

Q What should be the actual rulling gradient if the rulling gradient is 1 in 200 in B.G. A curve is 2° in super impost on the over

DATE

PAGE NO.

track system is B.G.

Ans: Compensation for 2° curve = 0.04×2 = 0.12 %

Ruling gradient 1 in 200 = $\frac{1 \times 100}{200}$ = 0.05 %

Max^m allowable gradient or actual gradient to be provided = 0.5 − 0.12 = 0.38

$\Rightarrow \frac{1}{0.38 \div 100}$ = 264.15 = 1 in 264.

(B) Speed of the train

(1) Where transition curve exists, The safe speed V in km·ph is given.

→ for BG and NG.

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

or

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

→ for NG, $V = 3.6\sqrt{R-6.1}$ or $V = 3.65\sqrt{R-6}$

Subjected to a max^m of 50 km

(2) Where transition curves are absent

→ for BG and MG

V = 4/5 that speed calculated in equation (A) above.

→ That is $V = 2.92 \times \sqrt{R-6}$, subjected to max^m of 40 km ph.

(3) For high speed.

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

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DATE

PAGE NO

Note - The max^m speed for transitioned curve is now determined of indian railways as per revised formulae given below.

(a) For B.G track - $V = \frac{(Ca + Cd) \times R}{13.96}$ Or $V = 0.27 (Ca$

where, V = maximum speed in km.ph.
Ca = Actual cant (i.e superelevation) in mm.
Cd = Cant deficiency permitted in mm.
R = Radius in meters.

(b) On Narrow gauge (NG) track - $V = 3.65 \sqrt{R-6}$.

SUPER ELEVATION

The method of working ~~out~~ out the speed of m line branch line and negative super elevati on branch line will be clear from the following steps -

(i) The equilibrium elevation or cant - on bra line is calculated by formula.

$$e = \frac{G \times V^2}{1.27 \times R}$$

(ii) The permissible cant efficiency is reduced fr the equilibrium cant as often in step 1.
(For BG cant)
deficiency = 7.6cm, for MG = 5.1cm, and NG = 3.8 cm.

(iii) The difference often (equilibrium cant, permiss ible cant efficiency) will give the negative elevation to because on the branch line.

(iv) This negative super elevation is also equal to the max^m super elevation permitted on the main curve track.

(v) The restricted speed on curve track is often by adding the permissible deficiency is max^m cant on the maintrack and applying the formula.

$$E = \frac{G \times V^2}{1.27 \times R}.$$

Q. Find out the speed for which super-elevation is to be maintain if the speed of several train running an a main curve track follows–

(i) 15 train at a speed of 50 km/hr.
(ii) 10 train 60 km/hr.
(iii) 5 train 70 km/hr.
(iv) 2 train speed of 80 km/hr.

Ans: Weight of average = $\frac{n_1 x_1 + n_2 v_2 + n_3 v_3 + n_4 v_4}{n_1 + n_2 + n_3 + n_4}.$

$$= \frac{15 \times 50 + 10 \times 60 + 5 \times 70 + 2 \times 80}{15 + 10 + 5 + 2}$$

$$= 58.125 \text{ km/hr.}$$

The devision often max^m speed = 80 − 58.125
= 21.875 km/hr.

DATE

PAGE NO.

Q: What is the equilibrium cant on a 2° curve on a broad gauge if 15 train, 10 train, 5 train, 2 train running at a speed of 50, 60, 70, 80 respectively.

Ans:

$$e = \frac{4V^2}{1.27 \times R} = \frac{1720}{D^\circ} = \frac{1720}{2} = 860.$$

$G = 1.676$, $V = 58.125$.

$$e = \frac{G \times V^2}{1.27 \times R}, \frac{1.676 \times 58.125^2}{1.27 \times 860} = 5.18.$$

For broad gauge you (BG) = $e = \frac{1.315 V^2}{R}$

Q. (i) On a BG 3° curve the equilibrium cant is provided for a speed of 70 km/hr, Calculate the value of equilibrium cant.

(ii) Allowing a max^m and deficiency what would be to the max^m permissible speed of the track.

Ans:

$$\frac{1720}{D^\circ} = \frac{1720}{3^\circ} = 573.33.$$

$$e = \frac{G \times V^2}{1.27 \times R} \Rightarrow e = \frac{1.315 \times 70^2}{573.33} = 11.25.$$

The critical cant = equilibrium cant + cant deficiency.

$= 11.25 + 7.6 = 18.85$

Speed permissible $= e = \frac{1.315 V^2}{R} \Rightarrow e \times R = 1.315 V^2$

$\Rightarrow e = \dfrac{G \times V^2}{1.27 \times R}$ $\quad V = \sqrt{\dfrac{[illegible]}{[illegible]}}$ $\quad$ [illegible]

$V = \sqrt{\dfrac{18.35 \times 573.3}{1.315}} = \sqrt{[illegible]}$ $\quad V = 90.5$ km/hr

According to railway board speed formula

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

$= 4.35 \times \sqrt{573.33 - 67} = 97.88$ km/hr.

$= 97.88 \simeq 98$ km/hr.

Hence the max^m^ permissible speed = 90.5 km/hr or 98 km/hr.

Q. A 5° curve diverged from a 3° main curve in reversed direction layer of a BG yard. If the speed on the branch line is restricted to 35 km ph. Determine the restricted speed on the main line.

Ans:

$G = 1.676$

$V = 35$ km/h

$R = \dfrac{1720}{5^\circ} = 344$

$= \dfrac{1720}{3^\circ} = 573.33$

$e = \dfrac{G V^2}{1.27 \times R}$

$= \dfrac{1.676 \times 35^2}{1.27 \times 344} = 4.71$

Then calculate the negative cant

$= 4.71 - 7.6 = -2.89$ cm.

Theorotical super elevation on the main line will be $= -2.89 + 7.6 = 10.46$ cm $= 10.5$.

$e = \dfrac{G \times V^2}{1.27 \times R} = \dfrac{1.676 \times V^2}{1.27 \times 573.33}$

$V^2 = \dfrac{e \times 1.27 \times R}{G} = \sqrt{\dfrac{e \times 1.27 \times R}{G}}$

$V = \sqrt{\dfrac{10.5 \times 1.27 \times 573.33}{1.676}} = 67.54.$