4. Geometric design of the track

Grade compensation on curves:-

→ 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.

→ This curve resistance is expressed % per degree.

→ Compensation for curvature is given

0.04 % per degree of curve for BG
0.03 % " " for MG
0.02 % " " for NG.

Radius of curves in meter 70/R for BG
52.5/R for MG
35/R for NG.

(Q) ① If the ruling gradient is 1 in 150 on a particular section of BG and at the same time a curve of 4 degree is situated on this ruling gradient, what should be the allowable ruling gradient?

A) As per IS compensation of BG is 0.04 % per degree of curve
$1^\circ = 0.04\%$.

Then, compensation for 4° curve $= 0.04 \times 4 = 0.16\%$.

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

So max^m allowable gradient or actual gradient = $0.67 - 0.16 = 0.51\%$.

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

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(Q) ② What should be the actual ruling gradient?
(a) If the ruling gradient is 1 in 200 on a B.G
(b) A curve of 3° is superimposed on the above track section of B.G.

Speed of the train:-

The speed of the train depends upon the strength of the track and the power of the locomotive.

For BG = 96 km.p.h
MG = 72 km p.h
NG = 40 km p.h

* With modernization of Indian Railways and use of electric traction it has now become possible to attain train speeds upto 160 km.p.h on BG routes and upto 100 km.p.h on MG routes.

Safe speed on Curves :-

Safe speed for all practical purposes means a speed which is safe from the danger of overturning and derailment.

Safe speeds on curves depends upon.
① Gauge of track ② Radious of the curve
③ Amount of super elevation
④ Presence and absence of transition curves.

(3)

In India followings formula given by martin where transition curves exist :-
for B.G and M.G (speed < 100 km ph)
Safe speed V in km p.h is given by

(i) $V = 4.35\sqrt{R-67}$ or $V = 4.4\sqrt{R-70}$ — (I) - eqn ①

(ii) for N.G $V = 3.6\sqrt{r-6.1}$ or $V = 3.65\sqrt{R-6}$

* Where transition curves are absent ; on non-transitioned curves.

① for B.G and M.G

$V = \frac{4}{5}$ th of speed calculated in eq ①
(80% speed is allowed)

(ii) For N.G = ($\frac{4}{5}$ th of speed calculated in (B) above).
$V = 2.92\sqrt{R-6}$

(iii) for high speed - (> 100 km ph), BG, MG
$V = 4.58\sqrt{R}$, V = speed in km.p.h.
R = Radius of curve in metres.

Cant deficiency :-

Cant deficiency = Equilibrium cant necessary for max^m permissible speed on curve — actual cant provided.

Equilibrium cant :-

When the lateral forces and wheel loads are almost equal, the cant is said to be in equilibrium. This equilibrium cant is provided on the basis of avg. speed of the trains.

(4)

→ Max^m Cant deficiency for gauges for indian Railway are

① B.G track — 75 mm
② M.G track — 50 mm
③ N.G track — 40 mm

(4)

→ Max^m Cant deficiency for gauges for indian Railway are

1. B.G track – 75 mm
2. M.G track – 50 mm
3. N.G track – 40 mm

Radius of Degree of curve :-

30 m Chain length

$2\pi R L = 360°$

$L = \frac{360}{2\pi R}$

for 30 m, $= \frac{360 \times 30}{2\pi R}$

$$D° = \frac{1780}{R}$$

→ Max^m degree of curvature for B.G = 10° (min R = 175 m)

→ Max^m degree of curvature for M.G = 16° (min R = 109 m)

→ Max^m degree of curvature for N.G = 40° (min R = 44 m)

Superelevation or cant :-

To counteract the effect of centrifugal force, the level of the outer rail is raised with respect to inner rail by a certain amount to introduce the centripetal force.

→ This raised elevation of outer rail above the inner rail at a horizontal curve is called Superelevation or cant.

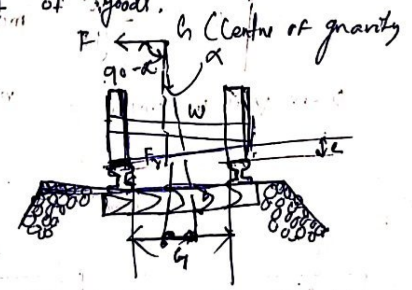
Objects of providing superelevation :-

→ ① To introduce the centripetal force for counteracting the effect of centrifugal force. This will also prevent derailment and reduce the side wear and creep of rails.

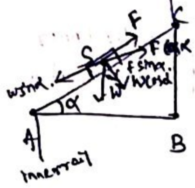
② To provide equal distribution of wheel loads on two rails, so there is no tendency of track to move out of position due to more load on outer rail.

③ To provide an even and smooth running track for comfortable ride to passengers and safe movement of goods.

for comfortable ride to passengers and safe movement of goods.



Relationship of super elevation (e), Gauge, Speed (V) and Radius of the curve (R) :—



- W = weight of moving vehicle
- v = Speed of vehicle m/sec
- V = Speed of vehicle km per hour
- R = Radius of curve (m)
- G = Gauge of track (m)
- g = Acceleration due to gravity in m/sec^2
- α = Angle of inclination
- S = Length of inclined surface in m,

- Centrifugal force = $F = m.a$

Radial acceleration $a = v^2/R$

$$F = \frac{W}{g} \times \frac{v^2}{R} \quad \text{— (1)}$$

$$F = \frac{Wv^2}{gR} \quad \text{— (1)}$$

Resolving the forces weight along inclined line

$$F\cos\alpha = W\sin\alpha$$

Means AC = S

$\cos\alpha = \frac{b}{h}$

$\sin\alpha = \frac{P}{h}$

$$\frac{Wv^2}{gR} \times \frac{G}{S} = W \times \frac{e}{S}$$

$$\boxed{e = \frac{Gv^2}{gR} \text{ metres } (v \text{ in } m/s)}$$

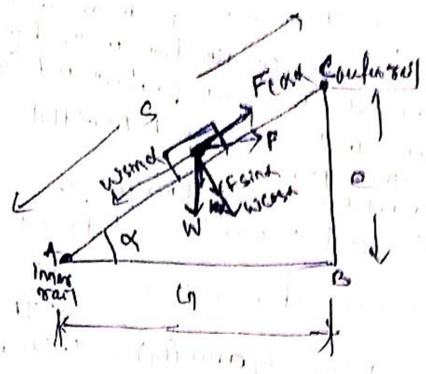
When V is in km/h =

$$e = \frac{v^2 G}{gR}$$

$$= \frac{\left(\frac{1000}{60 \times 60}\right)^2 V^2 G}{gR}$$

$$= \frac{(0.278\,V)^2 G}{9.81\,R}$$

∴ $\boxed{\text{If R in cm } = e = \frac{V^2 G}{127 R}}$ $\boxed{e = \frac{V^2 G}{127 R} \text{ Metre}}$



Negative super elevation