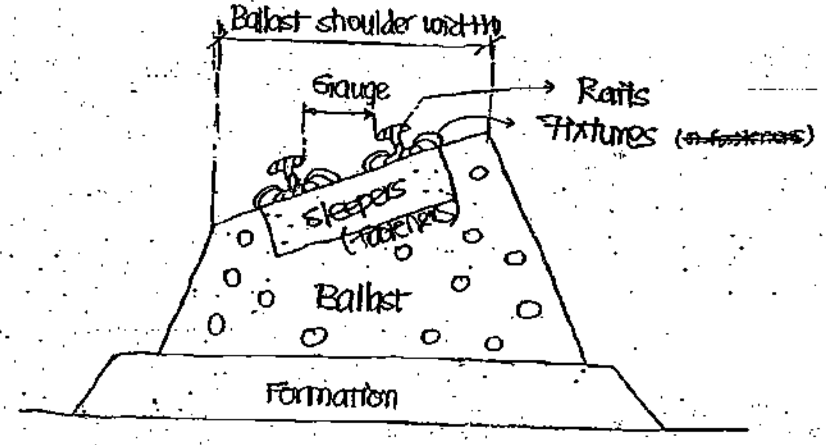
Railway Engineering

Introduction :

1. Cross section of a railway track :



Important components : (i) formation (iv) Fixtures
(ii) Ballast (v) Rails.
(iii) Sleeper

2. Gauge :

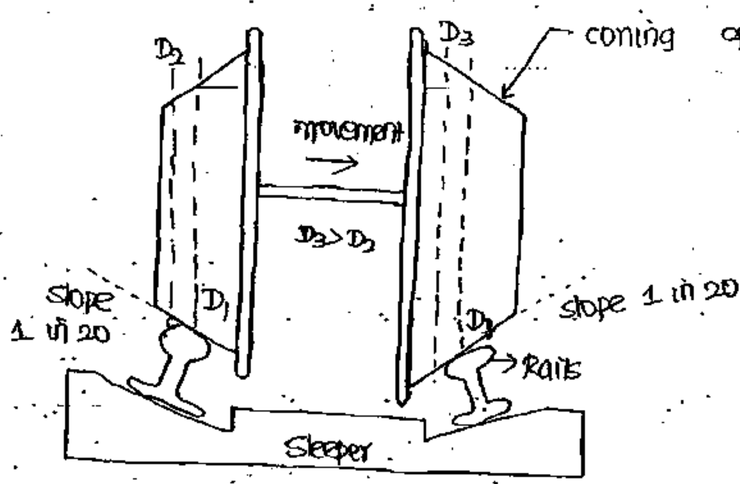
Distance between inner faces of the two rails (running face). Running face is the face on which flange of wheel will be there.

1. Broad Gauge (B.G) = 1.676 m
2. Meter Gauge (M.G) = 1.0 m
3. Narrow Gauge (N.G) = 0.762 m
4. light Gauge (L.G) (Feeder track gauge) = 0.610 m

5. Standard gauge S(G) = 1.435 m (other countries & metro).

Coning of wheels :

#. The wheels are made cone shaped having different diameter at different cross section. Diameter near flange is more than diameter near other ends. The rails are also laid at a slope of 1 in 20 (same slope of wheel face). This is called coning of wheels.

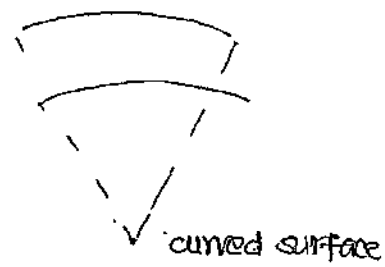


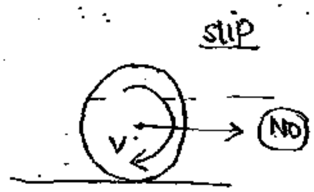
Purpose : ① On a straight track : to keep the wheel assembly in central position to avoid derailment.

② To reduce wear & tear of wheels as well as rails.

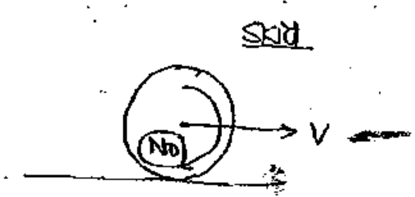
③ On a curved track : Due to centrifugal force, the wheel assembly will move in outward direction, so diameter on outer rail will increase. so the distance travelled in outer rail will become more as required.

Due to difference of dia on two rails, the train will be moving on a circular track will be adjusted as required. only some part of difference is adjusted by coning. Remaining part is covered by slip or skid on the surface.





At the time of acceleration



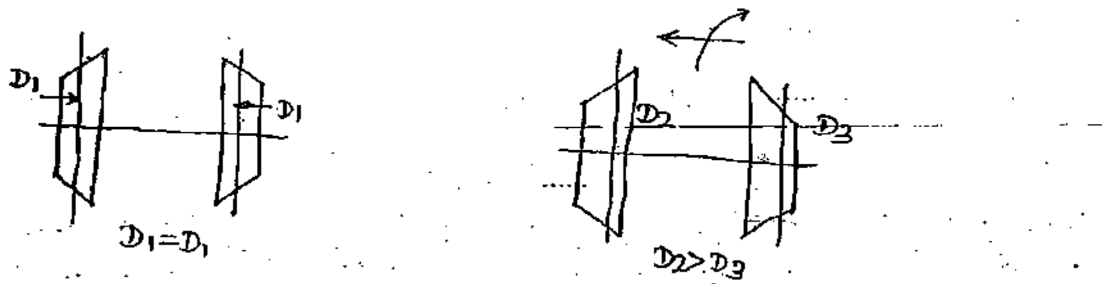
At the time of brake

Theory :

Due to cone shaped wheels, dia of wheel is not same at each cross section.

On a straight track :

The wheel will always move in central position in such a way that diameter at contact point with rail is same on the two rails. If the train (axle of wheel) try to move in any direction, diameter of wheel on one rail will increase so the axle will start moving on a circular track, thus the wheel assembly will be automatically returned back in its central position.



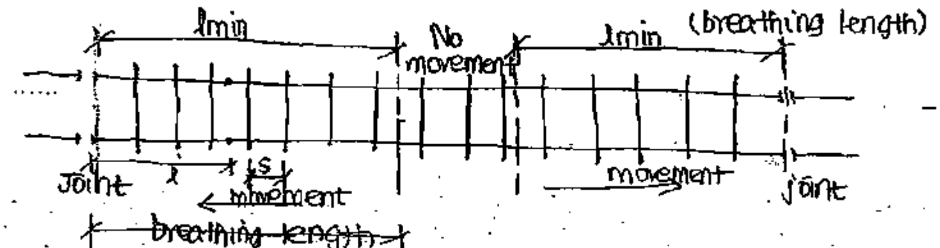
central position

On a curved track: The distance on the two rails are partially adjusted due to centrifugal force due to which the train moves in outward direction, due to which dia on outer rail becomes more than dia. on inner rails.

3. Welded Rails (Long Welded Rails) LWR :

The rails are made of a particular length (for BG track, max. length 12.8 m is used). The joints to be provided in the railway tracks are one of the weakest locations. To avoid joints, rails are welded together.

⊕ Long welded rails are used where all the rails are welded for a long length. The stresses caused due to difference of temperature are arrested by the fastures and rails are not allowed to move. so no expansion joints are required. A minimum length is required to avoid the movement of rail due to temperature variation.



If l = length of rail on one side. Increase in length due to T° temp. variation.

$$\delta l = l.\alpha.T$$

If no movement is allowed in the rail (strain not allowed)

$$= \frac{\delta l}{l} = \alpha T.$$

$$\frac{\text{stress}}{\text{strain}} = E_s \text{ (Young's modulus of steel)}$$

stress develed in rails due to not allowing the movement of rail.

$$\text{stress} = \text{strain} \times E_s$$

$$p = \alpha.T.E_s.$$

Force developed in rails, $P = A \times p$

$$P = A.\alpha.T.E_s.$$

This force will be resisted by the fasteners (sleepers)

If one sleeper can resist 'R' force, min. no of sleepers required to stop the movement of rail.

$$n = \frac{P}{R} = \frac{A \cdot \alpha \cdot T \cdot E_s}{R}$$

Min. length in one direction so that there is no movement in rail due to temp. variation.

$$(l_{min})_{one\ direction} = (n-1)s$$

Minimum length of long welded rail (so that there is no movement at central position) = $2 l_{min}$

⊕ In central position There is no movement of rail because sufficient number of sleepers are available in both direction to stop the movement.

⊕ Breathing length: At both ends upto l_{min} distance from expansion joints, some movement of rail will be observed because no. of sleeper is less in one direction. These two end portions are called breathing length.

Q.5.a Define & explain breathing length of LWR
ES2001

II) Determine the min. theoretical length of LWR beyond which the central portion of a 52 kg rail would not be subjected to longitudinal movement due to 30°C temp variation. Use following data.

A. rails

c/s area = 66.15 cm²

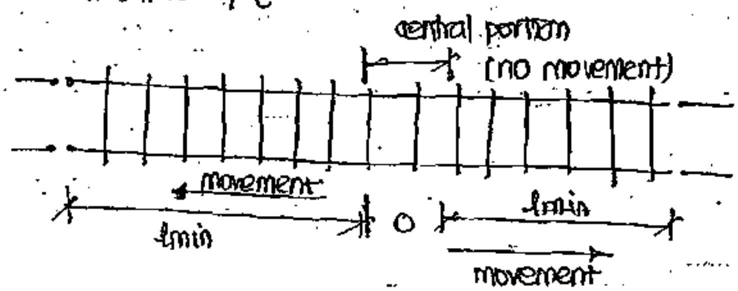
$E_s = 2.1 \times 10^6$ kg/cm²

$\alpha = 11.5 \times 10^{-6}$ /°C

B. sleepers

spacing = 60 cm

Average resistance force / sleeper / rail = 300 kg.



#. Due to temp. variation force developed in rail section.

$$P = A \cdot \alpha \cdot T \cdot E_s$$

$$= 66.15 \times 2.1 \times 10^6 \times 11.5 \times 10^{-6} \times 30$$

$$P = 47925.625 \text{ kg}$$

#. min. no. of sleepers req. to resist this force

$$n = \frac{47925.625}{300} = 159.75 \text{ i.e. } 160$$

#. min. length in one direction

$$l_{min} = (n-1)\,s = (160-1) \times 60 = 9540 \text{ cm}$$

$$= 95.4 \text{ m.}$$

(breathing length)

#. min. length of LWR = $2 l_{min}$ = 2×95.4 = 190.8 m

4. Sleeper density :

#. Number of sleepers used for one rail is called sleeper density.

#. denoted by (n+x)

n → length of one rail in meter (For BG track = 12.8 m ≃ 13 m.)

#. Generally sleeper density is kept from (n+3) to (n+6).

Eg. calculate total no. of sleepers req. for 5 km railway track if sleeper density is n+5 for a BG track.

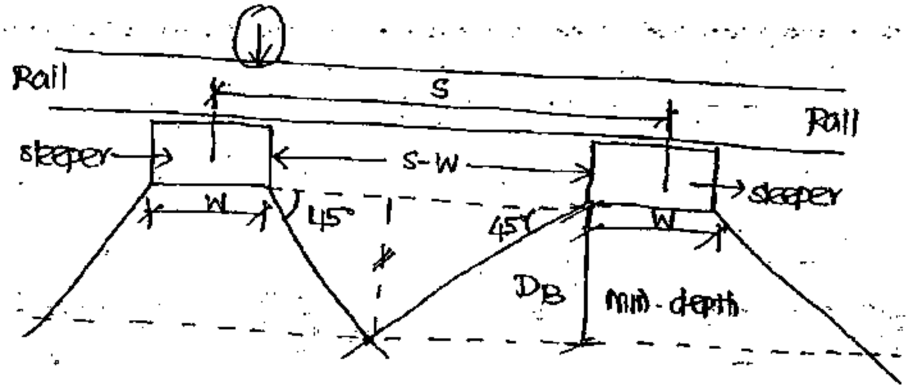
One rail length = 12.8 m ≃ 13 m

No. of sleepers used = (n+5) = (13+5) = 18

Total no. of sleepers for 5 km = $\frac{5000}{12.8} \times 18 = 7031.25$

say 7032 sleepers.

#. Minimum depth of Ballast cushion :



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— D_B → depth of ballast.

If S = spacing of sleepers

W = width of one sleeper

min. depth of ballast cushion required, $D_B = \frac{S-W}{2}$

Geometrical design :

① Design speed :

Design speed shall be minimum of the following :-

(i) max. speed allowed by railway (max. sanctioned speed)

(ii) max. speed allowed on a curved track (as per radius). (speed as per Martin's formula).

(iii) As per super elevation provided (super elevation or cant).

(iv) As per length of transition curve.

#. Martin's formula :

(i) For transition curve : (where transition curve have been provided with simple curve).

a) For BG and MG track :

$$V = 4.35\sqrt{R-67} \quad \text{(Kmph)}$$

b) For N.G track :

$$V = 3.6\sqrt{R-6.1} \quad \text{(Kmph)}$$

$R \rightarrow$ radius of curve in meters.