SEMESTER - 5TH

Jyotsnarani Behera

→ Railway is a branch of civil engineering which deals with construction and maintenance of railway track for safe and efficient movement of trains on it.

Railway tracks are divided into 2 parts.

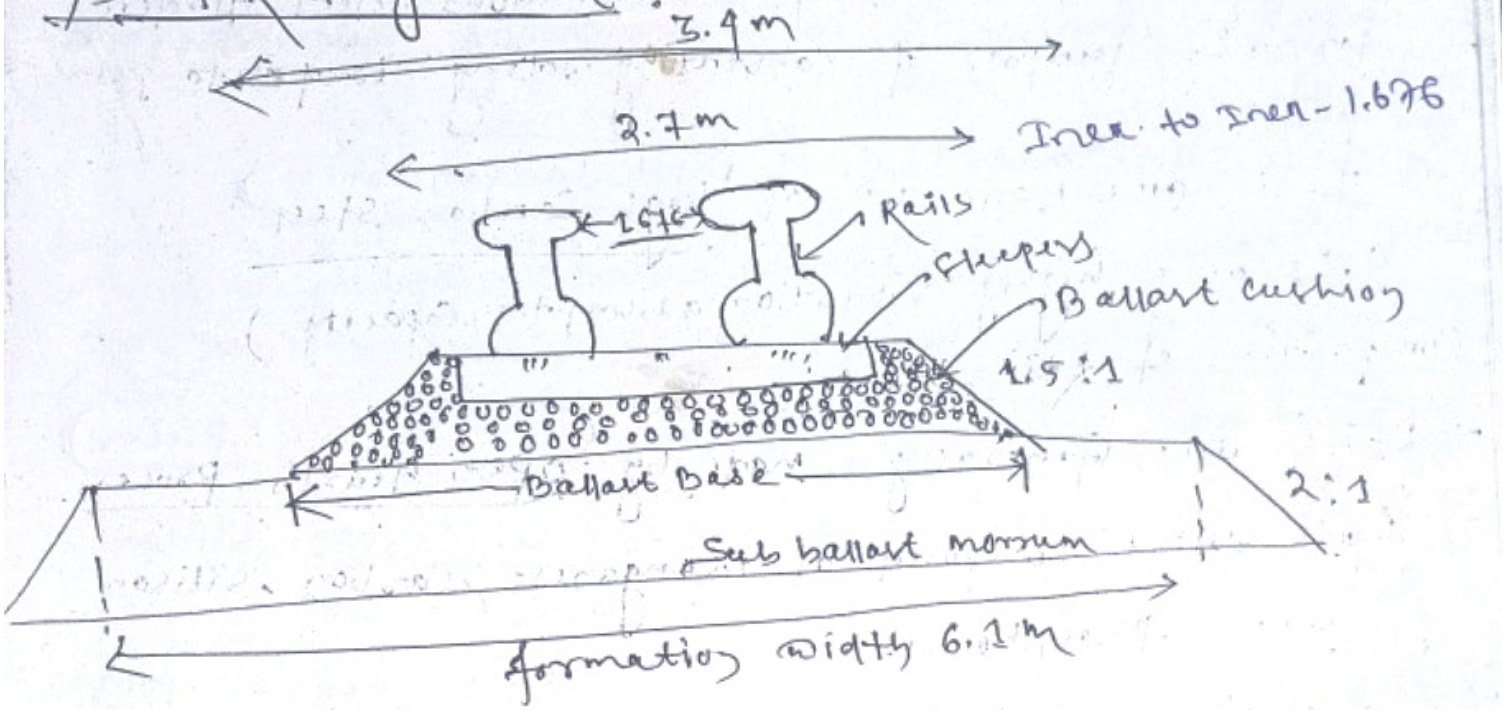
① Temporary railway track :-

These tracks are provided for transportation of earth and construction materials.

② permanent railway track :-

These tracks are provided for movements of trains.

C/s of Railway tracks :-



→ Railway tracks are divided on the basis of gauge distance.

→ It is the distance between running faces (Inner faces) of the rails.

① Broad Gauge - 1.676m

② Metre Gauge - 1m

③ Narrow gauge - 0.762m (used on hilly Area)

④ Feeder Gauge - 0.610m (un developed Area)

* Standard Gauge = 1.435m (metro)

Factors Responsible for selection Gauge :-

(I) Cost of construction
(II) Volume and nature of traffic
(III) Development of under developed area
(IV) Physical features of the country
(V) Speed of vehicle movement

Note
On important section in India Broad Gauge is preferred.

Rails :-

→ Rails can be considered as continious steel Girders for the purpose of converting rolling load into point Load.

→ These are made up of high Carbon steel.
(because highly vibration absorption capacity)

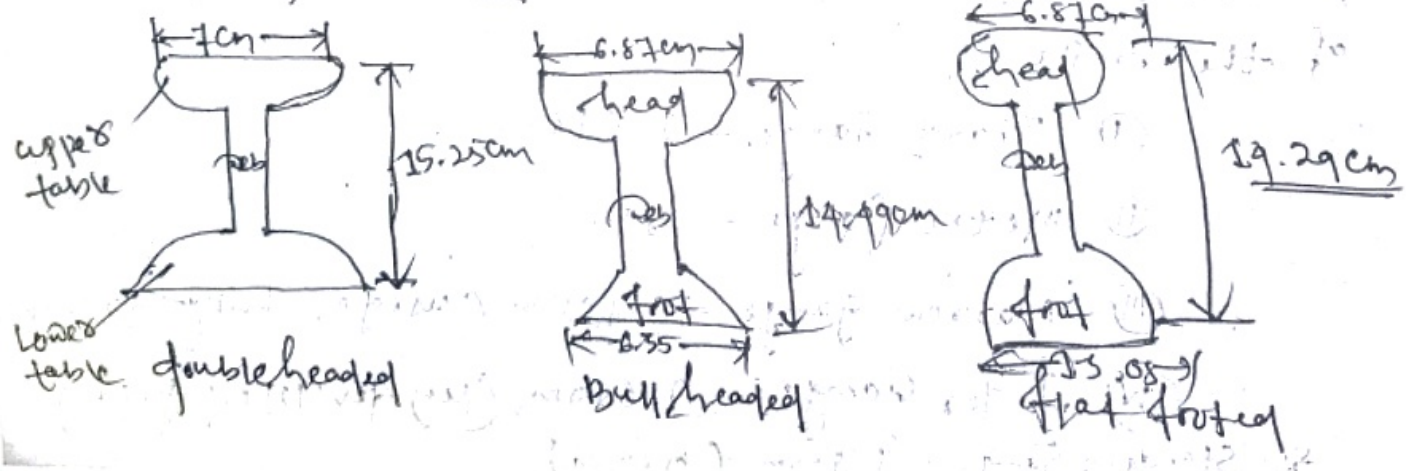
Composition of Rail Steel :-

→ Rails are Generally made by Open hearth process.

→ Rail steel composed of manganese, Carbon, silicon, Sulphure, phosphorous.

→ For ordinary Rail high Carbon steel and rails on point and crossing medium Carbon steel.

Type of Rail section



Double headed rails.

→ Initially Idea was to used to both the sections, both experience prove that could not be possible for smoot running of train over the another surface.

Bull headed rails:

→ These types of rails can change easily but requires high maintenance cost.

Flat footed rails

These types of rails have more strength and stiffness both in vertical and lateral direction than bull headed rails.

The main disadvantage is impact of rolling wheels and that distrubs the alignment gives Lesser stability, hence regular maintenance is required.

Mostly used in Indian railway track

Rail section are available:-

52 MR ⇒ 52 kg/mt & provided upto 150 km/hr

60 MR ⇒ 60 kg/mt & provided upto 160 km/hr

Length of Rail:-

BG = 12.8 mt.

MG = 11.89 mt

NG = 12 m

1 m = 3.28'
1' = 12"
1" = 2.54 cm
1' = 30.4 cm

Buckling of Rail:-

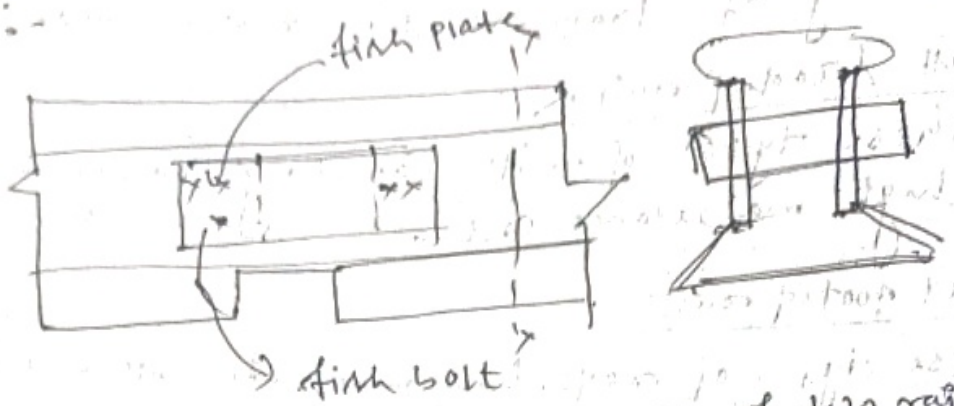
Due to increase in temp, if there is not sufficient amount of expansion space buckling of rail will happen and it will cause derailment.

Rail Joints:-

→ Rail Joints are necessary to hold the rail section in correct position.

→ Rail Joints have almost 50% strength of the rails.

Fish Plates :-



→ These plates are provided for continuity of two rails at rail joints and also provide the required gap for expansion and contraction due to variation in temp.

Fish bolt

→ 4 nos. of bolts are required for every connection and these are made up of medium or high carbon steel.

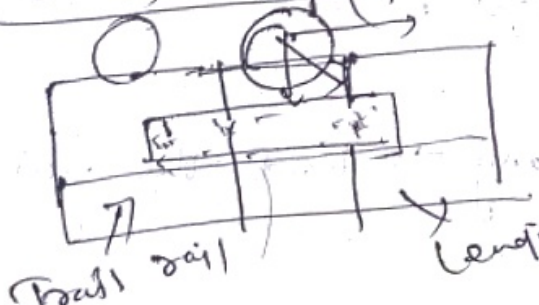
Creep of Rails

Longitudinal movement of rails w.r.t sleeper is called creep of Rails.

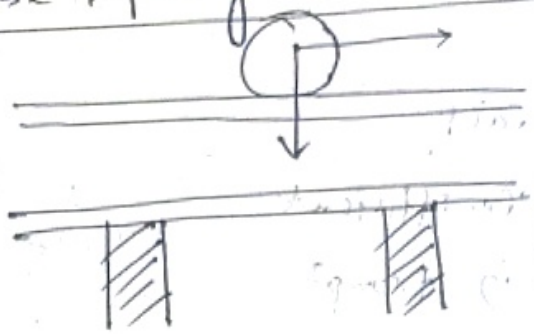
→ Creep of Rails do not vary with uniform rate and not continious in any particular direction.

→ Some theory try to explain the phenomena but do not give any satisfactory resolve.

(1.) Percussion Theory (At rail joint)



② Wave theory
(if we increase spacing between sleepers)



③ Drag theory :- (Dominating Traffic)
ex:- electric railway track

④ Due to Starting, braking effect and Acceleration.

Ex:- crow bar

⑤ Steel Sleepers

Welding Process :-

→ No. of Joints can be reduced by applying welding.
→ Welded Joints are economical but these are not provided for curves to avoid lateral thrust (due to centrifugal force)
→ Welding of rails reduces creep of rails. (Avoid percussion theory)

Types of welding method :-

① Flash - Butt Welding (Depot)

A powerful current is passed through the rail section & when they are heated upto required temp then a high pressure is applied to connect a rail section.
This method is used only in workshop.

② Thermit Welding (Al, Fe)

→ for field condition it has been proved that up to experimentally

5 Welded rails expansion will be same as per rail length (12.8m)

Calculation

l = Length of rail

α = Temp' of Co-efficient

$T°C$ = Change in temp'

Variation in Length of rail

$$\Delta l = l \alpha T$$

$$\text{Strain} = \frac{\Delta l}{l}$$

$$\frac{\text{Stress}}{\text{Strain}} = E$$

$$\text{Stress} = E \alpha T$$

$$P = A E \alpha T$$

$$P = A E \alpha T$$

RS = Registance offered by one Sleeper

n = no. of Sleeper = $\frac{P}{RS}$

Length of Rail required in one direction $L = (n-1)s$

Where, s = Spacing between Sleepers.

Notes

~~Total minimum length required in one direction~~

Total minimum length of LWR, so that the central portion does not move = $2L$

Types of Welded rails :-

1) Short Welded Rails (SWR) is the rails which expands and contracts through out its entire Length due to temp' variation.

Ex:- 3, 5, 10 rail Lengths are Welded together.

(ii) Long Welded rails (LWR) is the rail which central portion is does not move any longitudinal direction.
Ex - 200m to 1000m.

(iii) CWR (Continious Welded Rails)
→ CWR is longer than 1 Km and extending from one station to another station.

Q/ Determine the minimum theoretical Length of LWR beyond which the central portion of 52MR rail would not be Subjected to longitudinal movement due to 30°c temp variation. use the following data

Area of s = 66.15cm²
$\alpha = 11.5 \times 10^{-6}$ /°C
$E = 2.1 \times 10^6$ kgf/cm²
S = 60cm
Rs = 300kg
t = 30°c

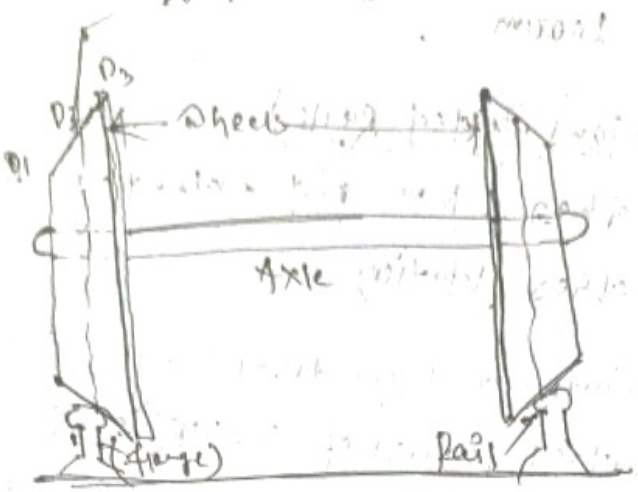
Ans:- $P = AE\alpha T$
$= 66.15 \times 2.1 \times 10^6 \times 11.5 \times 10^{-6} \times 30^\circ$
$= 47925^\circ 40' 30''$

$n = \frac{P}{Rs} = 159.75$

~~$2l = (159.75 - 1) 60 \times 0.6$~~
$= 9525$
~~$l = \frac{9525}{2}$~~

LWR = 2l
$= 2 \times (n-1) s$
$= 2 \times (159.75 - 1) \times 0.6$
$= 190.5$

Coning of Wheels :-



→ Wheels are made up cone shape having different diameters and diff. cross-section.

→ Dia. near the flange is more than dia. near the other end and this is called Coning of Wheels

Purpose of Coning :-

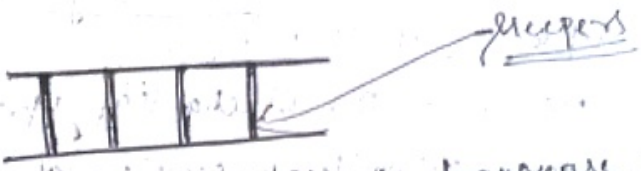
→ To keep the train just in central portion during the movement of trains.

→ To reduce the wear and tear of wheel flanges and rails.

→ To adjust a distance travelled by wheels on a curved tracks. When a longer distance is required to travelled outer railway track due to centrifugal force.

→ On a straight track when axle moves side wise in any direction dia. of wheel on one rail will increase and it will decrease in another rail. This prevents further movements of train and axle retreats back to it's original position.

SLEEPERS :-



→ Sleepers are provided or placed transverse to the rails.

→ Sleepers transfer point Load to from rail to ballast as line Load.

→ Sleepers act as an elastic medium in between rail & ballast to absorb the Load & vibration of moving loads.

Classification of Sleepers

(I) Wooden Sleepers

(II) Metal sleepers
- (a) Cast iron Sleepers
- (b) Steel Sleepers

(III) Concrete Sleepers
- (a) Reinforced concrete Sleepers
- (b) pre-stressed concrete Sleeper

Note
Wooden Sleepers are best Sleeper but their life is less as compared to steel and Concrete Sleepers.

Hard Wood Sleepers → Sal, Teak etc.

Soft Wood Sleepers → Deodar, Chir etc.

* for bridges and points and crossing Longer Sleepers of thicker section i.e 25cm x 15cm or 25cm x 18cm are used in railways.

Composite Sleeper Index (C.S.I)

→ It is an Index to determine Suitability of a particular timber for used as a Sleeper.

→ This Index measures the mechanical strength of timber derived from its composite properties of strength and hardness.

$$C.S.I = \frac{S + 10H}{20}$$

Where, S = strength Index of timber at 12% Moisture content.

H = Hardness Index of timber at 12% moisture content.

Imp

Types of Sleeper — Minimum CSI

Track Sleeper ——— 705

Crossing Sleeper ——— 1352

Bridge Sleeper ——— 1455

→ Steel sleeper are good but maintenance is difficult as their heavy and arrangement is complicated.

→ Concrete sleepers are used high speed train movement

Prestressed concrete sleeper

→ The max^m permissible compressive strength 211 kg/cm^2

→ Minimum Cube crushing strength at 28 days = 422 kg/cm^2.

→ The prestressed wires are stressed to an initial stress of 8.82 kg/cm^2

Sleeper density :—

No. of Sleeper per rail Length are denoted by

M+1 or N+1

Where, M & N = Rail Length. (3m or Yard)

x = Varying according to the factors of axle loads, types and section of the rails, type and strength of sleepers.

Note:-
The no. of sleepers per rail varies in India from M+4 to M+7

Q/ using a sleeper density of M+5, find the nos. of sleepers required for constructing a rail Bay track is 640 m. (B.G track).

Ans:- M+x = M+5
= 12.8+5
= 17.8

Length of Rail = 12.8 (BG)

Total no. of rails Required = $\frac{640}{12.8}$ = 50

Sleeper density = M+5
= 17.8 ≈ 18

Total nos. of sleeper Required = 50 × 18
= 900 sleepers.

Q/ find out the expression per sleeper density for a B.G, if 19 sleepers are used under a rail length.

Ans:- B.G = 12.8 ≈ 13m

Sleeper density = 19

SD = M+x
19 = 13+x
19-13 = x
6 = x

12.8 ≈ = 13
Sleeper density = 19
SD = 19-13+x
x = 19-13
x = 6

Ballast :-

→ It is a granular material (broken stone, bricks Kankar, etc.) and used to transfer line load from sleepers to subgrade soil as UDL.

→ They are provided for good drainage and some amount of elasticity in the tracks.

Size and section of ballast :-

→ Best size for ballast is 1.9 cm to 5.1 cm which gives more stability and interlocking.

→ The exact size of ballast depends upon the types of sleeper used and location of the track

(i) Wooden sleeper track - 5.1 cm Ballast

(ii) Steel sleeper track - 5.8 cm Ballast

(iii) for points & crossing - 2.54 cm Ballast

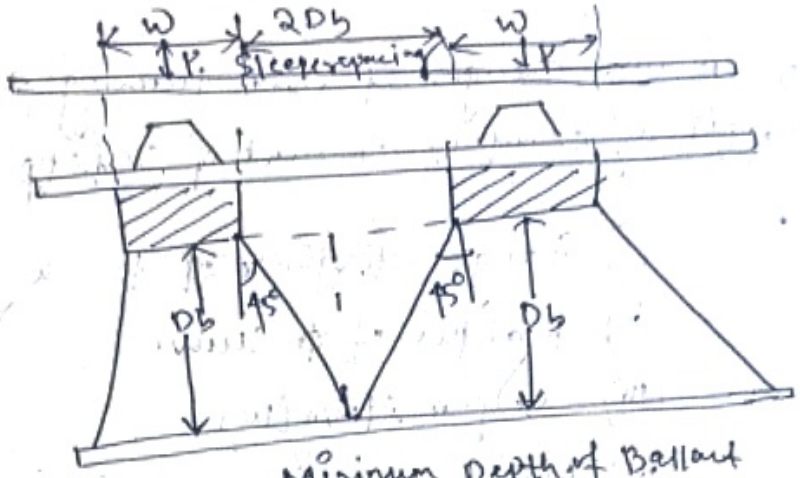
→ Max^m width of ballast layer is 38 cm to 43 cm but on curves outer railway track side width should be increased by 15 cm.

→ Depth of ballast gives good bearing capacity and to calculate depth of ballast we assume load dispersion at 45°.

→ pressure bulb is created where load is dispersed if the spacing between the sleepers is increased then the elasticity reduced.

→ In local tracks we have ballast so elasticity but where we have no ballast cement concrete is provided hence we will find elasticity.

→ Size of ballast is based on: Load dispersion, drainage, Interlocking, Compaction, elasticity.



Minimum Depth of Ballast

Sleeper Spacing = Width of Sleeper + 2× depth of ballast

$S = W + 2D_b$

Minimum Depth of ballast = $D_b = \frac{S-W}{2}$ $\quad D_b = \frac{S-W}{2}$

→ Sleeper spacing 65 cm

Width of Sleeper = 25 cm

Find Depth of ballast?

$D_b = \frac{65-25}{2} = \frac{40}{2} = 20\text{cm}$ (Generally prescribed by Indian railway)

Note:-

$$\frac{\text{Weight of the rail in tonnes}}{\text{Locomotive axle Load in tonnes}} = \frac{1}{510}$$

Thus for a locomotive of axle load of 22.86 tonnes the wt. of rail required will be = $22.86 \times \frac{1000}{510}$

$= 44.82\text{ kg}$

Geometric design of track :-

Safe speed (V)

Which is safe from danger of over turning and derailment with a certain amount of safety and depends on.

(I) Gauge distance of track
(II) Radius of curve
(III) Super elevation
(IV) Absence or presence of transition curve

Max^m speed allowed in a railway track is decided by considering the following cond^n :-

(I) Max^m speed is approved by railway board
(II) Speed is calculated by Martin's formula
(III) Safe speed as per super elevation formula.
(IV) Max^m speed as per Length of transition curve
(V) Strength of track & power of locomotive.

Martin's formula :-

Max^m speed allowed on a curved track -

(a) On a transition curve (< 100 kmph)
   (I) for BG/MG Track $V_{max} = 4.35\sqrt{R-67}$ kmph
   (II) for N.G Track $V_{max} = 3.6\sqrt{R-60}$ kmph

(b) On Non-Transition curve
   for B.G/M.G/N.G Track
   V_{max} = 80% Speed of Transition Curve.