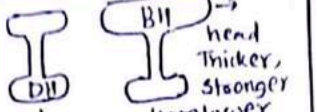
RAILWAY ENGINEERING

Parameter	Vignole's rails or Flat footed rails (FF)	Bull headed rails (BH) & double headed rails (DH)
Cross section	 52 MR (52 kg/m) upto 130 kmph; 60 MR (60 kg/m) upto 160 kmph	 पहले कार लगाते थे लेकिन यही लेकिन पहले ही समाप्त हो गयी
Strength & Stiffness	for same weight more	for same weight less
laying & relaying	simple	Difficult
initial cost	∵ fastner less & cost less thus initial cost Less	∵ fastner more & costly hence initial cost hight
M&R cost	Less	more

Defect on rails :

① Corrugated or roaring rail

- consist of minute depression on surface of rail
- created where either breaks are applied or train start
- when train passes over it - roaring sound occures

Solution → Grinding the rail top head

② Kinks or Shoulders

- when ends of adjoining rails, moves slightly out of position Kink formed.

Solution * By correcting alignment at joint and at cusved locations.
* proper packing of joints
* Proper maintenance of track Periodically in respect of cross-level, gauge, alignment, welding of worn out portion.

③ Hogged rails

- due to battering action (repeated hitting or impact action of wheel at the end of rail, the rails get bent down and get deflected at ends.

Solution : ① Dehogging ② welding ③ replacing ④ cropping

- occures due to loose packing of ballast, loose fish plate at joints.

④ Buckling of rail

- if sufficient gap / expansion joint is not available, the thermal expansion will not accomodate within the expansion joint which will Create thermal stresses in rails, rail will buckle.
- Buckling also occures if fish plate are bolted so tighly that rails are not allowed to slip or expand.

Solution :- ① Lubrication ② fish plate not too tight ③ expansion Gap.

⑤ Scabbing of rails

- due to falling of patches, chunks of metal from rail table.
- Shape → elliptical depression, whose surface reveals a progressive fracture with numerous cracks around it

⑥ Wheel burns

- cause by slipping of driving wheel of Loco. on rail surface, due to this extra heat generated and Surface of rail gets affected, resulting in depression on the rail table
- wheel burn are generally noticed on Steep gradient or there are heavy incidence of braking or near water column

⑦ Shelling and blackspots

- Progressive horizontal separation of metal that occures on gauge side generally at upper Gauge corner.
- cause due to heavy bearing pressure on a small area of contact, which Produces heavy internal shear stress.

Important Test on rails :- to determine servireability of rail section

1- falling weight Test	done at every cast of 100 metric ton
2- Tensile Strength Test	min = 72 kg/mm²
3- Hammer Test	

Chemical Test

① fish plate :- connect one rail to another rail (to maintain continuity of joint)

② sleeper :- ↓↓ • transfer point load into udl load
• maintain gauge

③ Ballast – • line load to udl load transfer
• Provide some elasticity to track

④ Rails :- converts rolling loads of wheel into – Points Load and transfer it to sleeper.

⑤ Track modulus :- Based on elastic theory
• index for stiffness / resistance of permanent way
• ratio of $\frac{\text{load}}{\text{unit length}}$ of rail, to produce unit depression in sleeper.

⑥ fastening → to fix rail with sleeper directly.

⑦ tie bar → fix rail to CI sleeper through a plate

⑧ crossing → at intersection of 2 rails

⑨ Spikes :- to hold rail on wooden sleeper

⑩ Chair :- used to support BH rails on sleepers

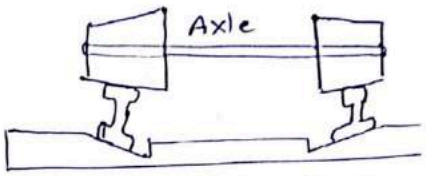
⑪ Bolts :- Dog / hook bolts where sleeper directly rest over steel girders.

⑫ Keys :- Small tapered piece of Timber, coated on steel, used to fix rails to chairs on – metal sleepers.

⑬ Bearing plate :- used below FH rails to distribute the load on large area.

Coning of wheels :- The distance b/w inside – edge of wheel flange is kept less than Gauge of track.

• wheel is coned to keep it in central position automatically, these wheels are coned at slope of 1 in 20.



• Advantages :-

1 – to reduce wear and tear of wheel flange and rail (which is due to rubbing action of flanges with inside faces of rail head.

2 – to provide possibility of lateral movement of axle with its wheel.

3 – to prevent the wheels from slipping to some extent

Adzing of sleeper or tilting of sleeper :-

for effective use of coning of wheels, the rails are not laid at horizontal, they are laid at a slope of 1:20 on sleepers

Creep of rail :- longitudinal movement of rail wrt sleeper in track.

Creep theory → wave action Theory
→ Percussion "
→ Drag theory

Causes of creep :- (i) rails not secured properly to sleepers
(ii) Inadequate Blast resistance
(iii) Badly maintained rail joints
(iv) Improper expansion Gap
(v) Lack of proper drainage
(vi) loose / uneven packing

effect of creep :- 1 – Buckling of track
2 – disturb Gauge & alignment of track
3 – Points & crossing gets distorted.

measurement of creep :- in 3 months interval

{BG max = 150mm creep}

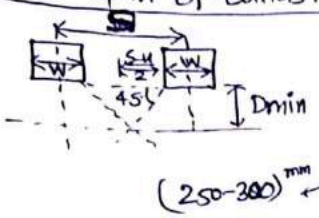
Composite sleeper Index (CSI):-

- measure mechanical strength of Timber
- derive from its composite property (strength (S), hardness (H))

$$CSI = \frac{S+10H}{20}$$

S → strength index
H → hardness index
@ 12% M.C

min. depth of Ballast section :-



$$\tan 45 = \frac{(S-W)/2}{D_{min}}$$

$$D_{min} = \frac{S-W}{2}$$

(250-300) mm

S = c/c dist b/w sleepers or sleeper spacing
W = width of sleeper

Survey work for Track Alignment :-

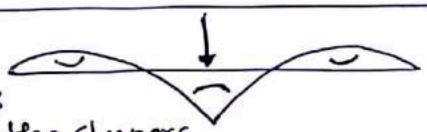
1- Traffic survey
2- Recannissance
3- Preliminary Survey
4- Detailed / Location survey

sleeper density :- no. of sleepers in rail Length

(M + x) → 3 to 7
↓
12-13

{ BG = 13 m
MG = 12 m }

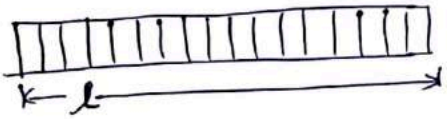
stresses on rail :-



- rail acts continuous beam carried on to the sleepers which provide elastic support

Length of welded rail :-

l → Length of rail



α ✓
T ✓
E ✓

- if expansion not allowed, thermal stress developed = $\alpha T E$

∴ Thermal force developed = $(\alpha T E)A$

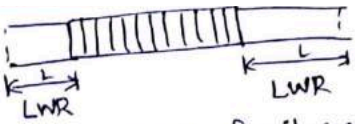
This internal force (f_s) resisted by sleeper.

Let resisting force per sleeper ⇒ R

∴ no. of sleepers (n) = $\frac{(\alpha T E)A}{R}$

∴ Length of welded rail = $(n-1)S$

Breathing Length :-



incase of LWR, the min. length of rail required to be welded at the end of track, so the portion of rail b/w welded rail does not undergo any thermal expansion / contraction is known as breathing Length.

breathing Length at both ends = $(n-1)S$

∴ total Breathing Length = $2(n-1)S$

Gradient → rise/fall in track level :-

1- Ruling Gradient (R.G)

- in most general case the max. Gradient allowed is known as RG
- Steep gradient required powerfull locomotive
- rising gradient followed by - falling gradient.
- Plain → 0.40 - 0.50 %
- Hill → 0.67 - 1 %

2- Momentum Gradient

The train while coming down in- falling gradient aquire sufficient- momentum this momentum gives additional KE to train this would enable the train to overcome a steeper rising gradient than- ruling gradient, this rising- gradient called Momentum Gradient. in such case the steeper grade than ruling grade is adopted

3) Pusher/helper gradient

Such severe gradient where- pusher or helper engine is- Provided at the end of the- train is known as pusher Gradient

note:- 1 in 75 and above, generally Pusher gradient is provided

note:- Restricting the gradient to the- ruling gradient in the hilly areas/ terrain → would mean increasing the Length of track resulting considerably in heavy excavation

4) Gradient in station yard

- to drain off water used for cleaning trains. It should be sufficiently low

Reasons :- ① to prevent the movement of standing vehicle.
② to prevent additional resistance at start of vehicle

at station yard < min gradient = 1/1000
max " = 1/400

Grade compensation on curve :-

Reduction in gradient, in order to avoid resistance beyond allowable Limit.

BG :-	$\min\left\{0.04\,\% \text{ per degree of curve}, \frac{70}{R}\right\}$
MG	$\min\left\{0.03\,\% \text{ ——}, \frac{52.5}{R}\right\}$
NG	$\min\left\{0.02\,\% \text{ ——}, \frac{35}{R}\right\}$

Safe speed limit As per martin's formula :-

- Low speed (< 100 kmph)
  - Transition curve → $V_{max} = 4.35\sqrt{R - 67}$ → BG / MG
  - non. T.C → Ref of TC
- High speed (> 100 kmph) → $V_{max} = 4.58\sqrt{R}$

Degree of Curve :-

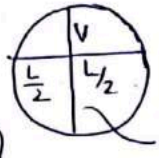
$$\frac{2\pi R}{360} = \frac{\text{Chain Length}}{D}$$

if chain Length 20 m		$D = \frac{1150}{R}$
"	30	$D = \frac{1720}{R}$
exact	30.48 or 30.50	$D = \frac{1750}{R}$

Gauge	max Degree of Curve	min Radius (m)
BG	10	175
MG	16	109
NG	40	44

Versine of curve :- used to check accuracy of curvature

$$V = L^2/8R$$



$$\{(2R - V)V = \frac{L}{2} \cdot \frac{L}{2}\}$$

$$\{2R >>>>>> V\}$$

Superelevation / cant 'e' :-

aim:- ① To counteract centrifugal force
Thus faster movement of trains.

② for comfortable ride.

③ To provide equal distribution of wheelload on 2 rail so that there is no tendency of track to move out of position due to more load on outer rail.

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

G: BG 1.676 m; MG 1 m; NG 0.762 m; Std. gauge 1.435 m

V. Imp

e (cm)	≤ 120 kmph	> 120 kmph
BG	16.5	18.5
MG	10	—
NG	7.6	—

equilibrium cant :- when pressure on both the rail equal then cant provided is known as eqb. cant & it is provided based on equilibrium speed.

$$V_{eqb} = \frac{n_1 V_1 + n_2 V_2}{n_1 + n_2}$$

When sanction speed > 50 kmph:

min { 1. $V_{eq} = \frac{3}{4} V_{max}$; 2. safe speed as per martin
(≤100 / >100 kmph)
BG $4.35\sqrt{R-67}$ $4.5\sqrt{R}$

< 50 kmph:

min { 1. $V_{eq} = V_{max}$; 2. martin formula ; 3. Superelevating formula $\left(e = \frac{GV^2}{127R}\right)$

Cant Deficiency (CD) = $e_{th} - e_{act}$
(e_{th} ↓ max. permissible speed; e_{act} ↓ avg. speed of trains)

CD limited to: ① Higher CD → more discomfort
② extra pressure and lateral force on outer rail

CD (cm)	≤ 100 kmph	> 100 kmph
BG	7.6	10
MG	5.1	–
NG	3.8	–

Cant excess ⇒ if speed is less than eqb speed
$CE = e_{act} - e_{th}$
for BG $CE = 75$ mm (7.5 cm)
MG $CE = 6.5$ cm.

Negative superelevation :- if Level of outer rail is below inner rail

Curve: Horizontal curve → if change in alignment direction; Vertical curve → if change in gradient

Transition curve :- 1- Introduced in b/w circular portion of track and straight track at both end 2- Radius of TC ∞ to R min
(∞ ↓ near straight portion of track; R min ↓ join point with circular curve)

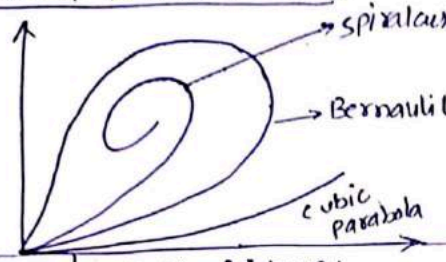
function :-

① Radius of curve decrease gradually to avoid sudden jerk due to centrifugal force.

② to provide gradual superelevation within length of transition curve

③ to provide gradual extra widening of rail.

Types of transition curve :-



(i) Spiral curve	• Used in highway ∵ curvature of curve deflection is more and highway spiral curves allowes deflection more than 9°
(ii) Cubic Parabola (Froud's curve)	• Used in railway because deflection allowed in track < 9° and within this limit cubic parabola traces spiral curve and setting is also easy • { setting out by offset method }
(iii) Bernaulis Lemniscati	satisfy requirement of TC upto deflection angle of 30°

Requirement of Ideal Transition Curve :-

① Transition curve should be perfectly tangential at 2 junction point, it means at straight junction its radius is infinite and at curve junction its radius must be equal to radius of curve.

② Rate of change of curveture = Rate of change of superelevation.

that full superelevation can be provided within the length of TC.

Cubic parabola TC :-

$$y = \frac{x^3}{6RL}$$

(i) Spiral angle ϕ :- Slope of tangent at any point on TC

$$\frac{dy}{dx} = \tan\phi = \frac{x^2}{2RL}$$

(ii) Deflection :- Slope of line joining any any point on curve to origin.

$$\frac{y}{x} = \tan\delta = \frac{x^2}{6RL} = \frac{1}{3}\tan\phi$$

$$\therefore \delta = 3D$$

δ → Spiral angle. D → Deflection

Length of Transition Curve

- M_1
- M_2
- M_3

max. { 7.2 e cm ; 0.073 e Vmax ; 0.073 C D Vmax }

M_2 : ≤ 100 kmph ; > 100 kmph

≤ 100 kmph : $V_{max} = \frac{134L}{e_{mm}}$ or $\frac{134L}{CD_{mm}}$

> 100 kmph : $V_{max} = \frac{198L}{e_{mm}}$ or $\frac{198L}{CD_{mm}}$

M_3 ⓐ Railway Board formula $L = 4.4\sqrt{R}$

ⓑ as per rate of change of radial acceleration $L = \frac{3.28V^3}{R}$

ⓒ as per rate of change of superelevation $L = 3.6e$

Shift (S) $= \frac{Ls^2}{24R}$

when a TC is fitted b/w straight & circular track, original curve is to be shifted inward by a certain distance, known as shift.

Widening of Gauge on curve :-

extra widening $Ew = \frac{13(B+L)^2}{R}$ (cm)

(m, m)

L = lap of flange $= 0.02\sqrt{h^2 + D.h}$ (meter)

(h in cm, D in cm)

B → rigid wheel base in metre

BG	6m
MG	4.88m

h → depth of flange below top of rail → (cm)

D → dia of wheel → (cm)

R → Radius of curve → (m)

Tractive effort :- pull applied by engine on driving wheels for movement of train

- if engine applies more power than HC, then driving wheel will slip

$$Te = \frac{\pi P d^2 L}{2D}$$

P → difference of pressure on 2 sides of piston
A → area of piston (d → dia of piston)
L → Length of stoke
D → dia of driving wheel
Te → tractive effort on wheel

Hauling capacity (HC) :- max. value of friction force that can be obtained from (b/w) rails & driving wheels.

$$HC = M \times \pi \times Wd$$

- M → coefficient of friction $= \frac{1}{6}(0.10 - 0.30)$ (↓ high speed, ↓ low speed)
- π → no. of pair of driving wheels
- Wd → (on each axle) weight of 1 pair of driving wheel

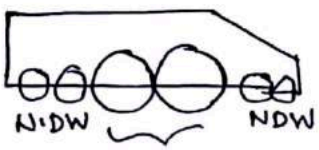
$M \propto \frac{1}{V}$

note:- max. axle load in India < BG = 20.32 t, MG = 17.34 t

locomotive designation Based on driving & non-driving wheels.

4 - 6 - 2 locomotive

- 4 → rare non driving wheels
- 6 → Driving wheels
- 2 → front non driving wheels



note:- for movement of Train
Te ≥ HC ≥ total resistance

Capacity of engine = min(Te, HC)

Total resistance :- {1 mile = 1.609 km ; 1 Nautical mile = 1.852 km}

(i) Train resistance

R_{T_1} (rolling resistance, resistance independent of speed)

$$R_{T_1} = 16 \times 10^{-4} W$$

R_{T_2} (resistance dependent on speed)

$$R_{T_2} = 80 \times 10^{-6} WV$$

R_{T_3} (atmospheric resistance)

$$R_{T_3} = 60 \times 10^{-8} WV^2$$

V → km/hr

(ii) resistance due to track Profile

- resistance due to gradient = $W \tan\theta$
- resistance due to curvature
  - BG = 0.04 % × W per degree of curve
  - MG = 0.03 %
  - NG = 0.02 %

(iii) resistance due to wind — max. when wind acting 60° to direction of train

(iv) Resistance due to Starting, acceleration, deceleration

R_{T_1} :- (rolling resistance, independent of speed)
resistance to the motion of train, running at constant speed is offered by friction b/w rails & wheels.

reason for R_{T_1} : (i) Journal resistance (friction of loco, wagon)
(ii) friction resistance (due to movement of steel wheel on steel rails)
(iii) track resistance (due to wave action of rail)
(iv) resistance due to internal part (resistance b/w cylinder & rim of driving)

Points & crossing

① made by HMS (High magnese steel)

② arrangement use to move train from one track to another track.

③ Provide flexibility of movement by connecting one line to another as per requirement.

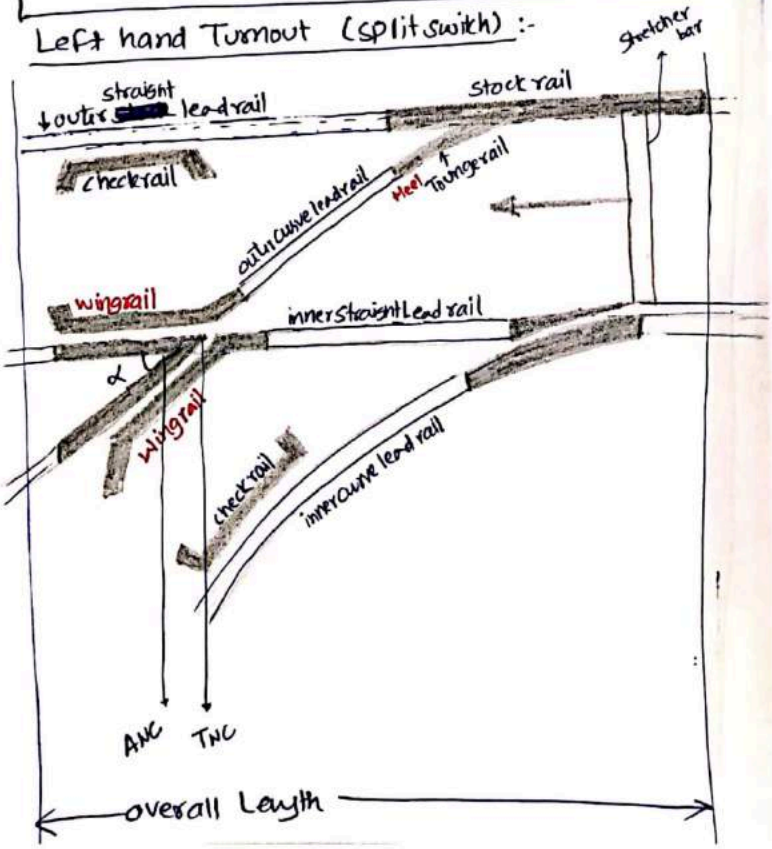
Turnout :- simplest combination of point & crossing which enables a track either branch line or siding to take off from main track.

Parts of Turnout :-

2 points or switch
2 Stock rail (1 pair stock rail)
2 check rail
a V crossing or acute angle or a crossing
4 lead rail < 2 curve lead rail, 2 straight lead rail

Studs
Bearing plate
Slide chairs
Stretcher bar
locking box
lock Bar
plunger Bar

Left hand Turnout (split switch) :-



Working principle of Turnout :

1- one turnout will provide facility to turn vehicle from one direction only (not from both the direction of turnout)

2- Turnout work with combination of point & crossing

3- point consist of
- 1 stock rail [part of outer straight lead rail]
- 1 tounge rail [part of outer curve lead rail]
- position of → 6mm higher than stock rail { so vertical wear does not exceed 6mm }

4- **Tounge rail :** It is tapered having toe at one end & heel at other end.
It is fixed at heel end and can move or rotate about this point

5- if [gap] b/w outer straight lead rail & toe of tounge rail → Then Train will pass through straight train
if [touches] → then Train divert on curve track (as shown as in Left hand Turnout figure)

6- **check rails :** (Guard rails) → introduced on curve, provided on opposite side of crossing
- Guiding one wheels of vehicle & Thus check the Tendency of other wheel to climb over crossing
- reduce wear of high rail Thus improve vehicle curve performance
- Provide parallel to inner rails on curve
- Bridge पर लगाते हैं।

7- **wing rail :** Guide the wheel path for movement of trains
- opposite to check rails
- helps in channelising the wheels in their proper route and directions means for their movement.

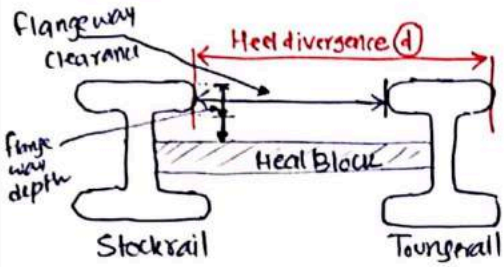
correct sequence from facing direction :-

1- Toe of switch (movable tapered end of tounge rail) → tounge rail (2) → Lead rail (3) → Crossing (4)

Other terms :-

1- Heel divergence/clearance (d) :-
distance b/w running face of stock rail & tounge rail at heel of switch.

BG = 13·3 – 13·7 cm

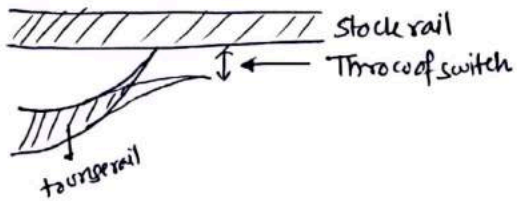


2- Flange way clearance :- distance b/w adjacent face of check rail and stock rail at heel of switch.

'or' dist. b/w the adjoining faces of the running-rail (stock rail) and the check rail near the crossing.

3- Flange way depth :- vertical distance b/w running rail (stock rail) & top of heel block.

4- Throw of switch :- (BG = 9.5cm)
max. distance by which toe of tounge rail moves sideway.



5- Switch angle α :- when tounge rail touches stock rail then —

- angle b/w running face of stock rail & tounge rail

note:- for smooth entry & movement of train (α_{min})

$\alpha \uparrow \Rightarrow$ slow moving train

$$\alpha = \frac{\text{Heel divergence}}{\text{tounge rail length}}$$

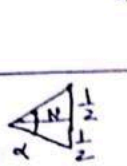
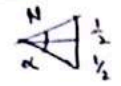
(6) - Stretcher Bar :- toe of both the tounge rail are connected together by a plate known as - Stretcher Bar.

(7) Types of switch (notused nowadays)

- Stub switch
  - no separate tounge rail
  - some portion of track is moved from side to side
- (Split switch)
  - tounge rail combined with stock rail
    - Loose heel type (Articulated type)
      - in this tounge rail joined By lead rail by fishplate
      - suit for short length switch
    - fixed heel type (flexible or spring type)
      - used with long tounge rail only
      - improvement over loose heel type.

Different methods to represent crossing angle (α)

$\alpha \downarrow \Rightarrow$ speed $\uparrow$

① Cole's method (right angle Triangle method)	 $N = \cot\alpha$ (N = no. of crossing) • use in railways	• Crossing angle.
② Centre line method	 $\tan\alpha/2 = \frac{(1/2)}{N}$	
③ Isosceles Triangle method	 $\sin\alpha/2 = \frac{(1/2)}{N}$	

BG Vmax (kmph)	N Crossing no.	Crossing angle α	Uses
–	1 in 6	$9°27'44''$	insymmetrical split
16	1 in $8\frac{1}{2}$	$6°42'35''$	Station yard where space limited
24	1 in 12	$4°45'44''$	Station yard of main Line
–	1 in 16	$3°34'35''$	High speed Turnout on BG/MG Track

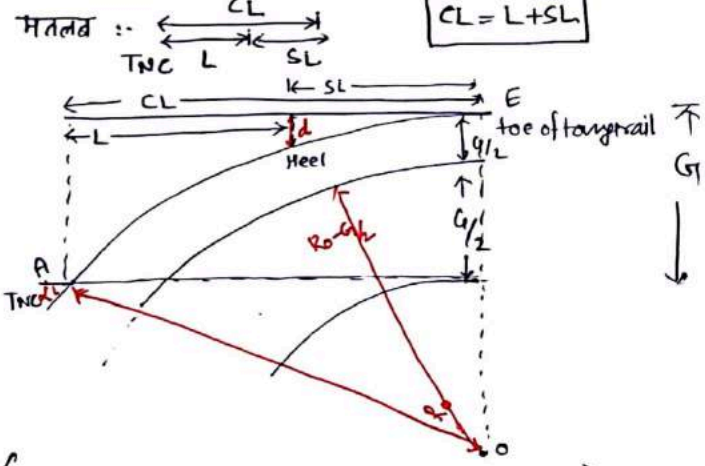
Design calculation of Turnout :

1- Curve lead (CL) :- distance measure along Stock rail b/w Toe of switch & TNC

2- Switch Lead (SL) :- distance b/w heel of switch and toe of switch measure along stock rail.

3- lead (L) :- distance b/w heel of switch & TNC

Hence :- $CL = L + SL$



{ outer radius $OA = OE = R_o$
central radius $R = R_o - G/2$
heel divergence 'd' = 13.3 – 13.7 BG (cm)
switch angle β crossing angle α }

case-1 :- when curve starts from toe of switch & end at TNC.

$CL = \sqrt{2R_oG} = 2GN = G\cot\alpha/2$

$R_o = 2GN^2 + 1.5G$ $\quad R = R_o - G/2$

$S_L = \sqrt{2Rd}$ $\quad CL = L + SL$

case-2. when straight arm x given & angle of switch β given

• Lead (crossing lead) $= x\cos\alpha + (G - d - x\sin\alpha)\cot\left(\frac{\alpha+\beta}{2}\right)$

• outer radius $R_o = \frac{G - d - x\sin\alpha}{\cos\beta - \cos\alpha}$ $\quad R = R_o - G/2$

case-3 :- if straight arm $x = 0$ then put zero in case-2 & solve

Crossover :- when 2 adjacent parallel or diverging tracks which may be straight or curved, are connected by 2 sets of Turnout, the connecting portion (line) is called crossover.

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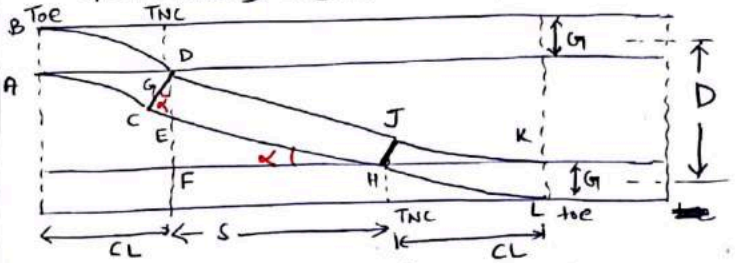
Type-1 :- crossover with straight immediate portion and equal crossing angle for both parallel track.



Total Length of crossover :- $CL + S + CL \rightarrow 2GN$ (L) $\quad 2GN$

now aim $\Rightarrow$ S ?? :- horizontal projection of intermediate portion of main track

$\Delta EFH \quad S = EF\cot\alpha = (DF - DE)\cot\alpha = [(D-G) - G\tan\alpha]\cot\alpha$

$S = \left[D - G - G\sqrt{1+\tan^2\alpha}\right]\cot\alpha$ $\quad \cot\alpha = N$

$S = \left[D - G - G\sqrt{1 + \frac{1}{N^2}}\right]N$

$S = \left[D - G - \frac{G\sqrt{1+N^2}}{N}\right]N$ $\quad$ put $\sqrt{1+N^2} \approx N$

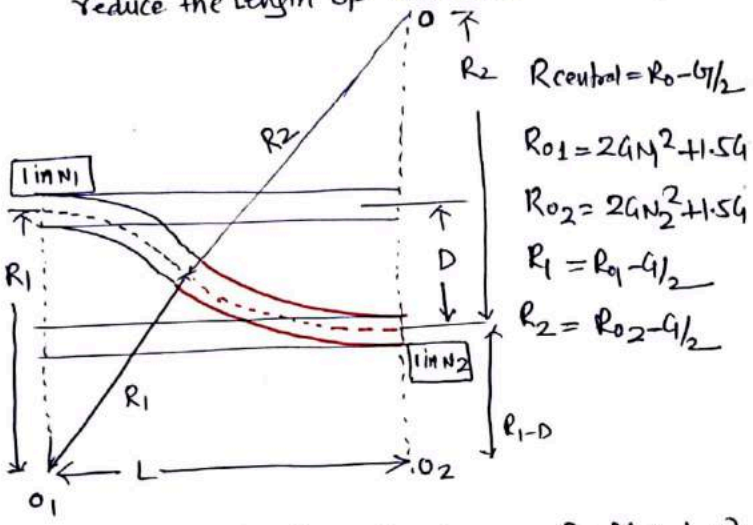
$S = DN - 2GN$ Ans.

$\therefore \boxed{L = 2GN + DN}$

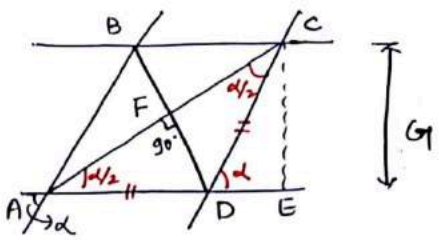
2GN (lead) DN (S)

Type-2 :- A crossover Intermediate portion curve & crossing angle may or maynot equal

{ Basically here use of reverse curve to- reduce the Length of crossover }



$\Delta OO_1O_2 :- (R_1+R_2)^2 = L^2 + (R_2+R_1-D)^2$ find L=?



ABCD → rhombous in which AB = BC = CD = DA

दो भुजा बराबर (AD = DC) ∴ दो कोण बराबर

$\angle DAC = \angle DCA = \alpha/2$

① $\Delta DEC :-$ $\tan\alpha = \frac{G}{DE}$ $\quad DE = G\cot\alpha = GN$

$\sin\alpha = \frac{G}{DC}$ $\quad DC = G\operatorname{cosec}\alpha = AD = AB = BC$

② $\angle AEC$ में :- $\sin\alpha/2 = \frac{G}{AC}$ $\quad AC = G\operatorname{cosec}\alpha/2$

③ $\angle AFD$ में $\quad \tan\alpha/2 = \frac{FD}{AF} = \frac{BD/2}{AC/2}$

$\therefore BD = G\operatorname{cosec}\alpha/2 \times \tan\alpha/2$

Type-3 :- Diamond crossing :- when straight track or curved cross each other at angle less than 90° , a diamond shape formed known as diamond crossing.

1- It can not transfer rails from one track to another track.

2- It consist → 2 acute angle crossing + 2 obtuse " + 4 check rails

3- In Indian railways :
flattest diamond to be 1 in 10 BG, 1 in $8\frac{1}{2}$ MG/NG

4- avoided because it reduces speed.

5- Length of Gap b/w 2 noses of an obtuse crossing increases as the acute Angle of crossing decreases.

Signalling :- consist of system, device and means by which trains are operated efficiently and tracks are used to max. extent and maintaining the safety of passenger and rolling stock.

- signalling includes → signals, points, other instrument

classification of signals :-

① on basis of operation	① Detonating (fog/audible) signal ② Hand signal } visual indication signal ③ fixed signal } visual indication signal
② on basis of function	① Stop or semaphore type signal ② Warner signal ③ shunting signal or disc or grd signal ④ colored light signal
③ on basis of Location	① Reception Signal → outer signal, Home signal ② Departure signal → Starter, advance starter
④ special type/ characteristic	1- repeater or co-acting signal 2- Routing signals 3- Calling on signals 4- Point Indicators

1- fixed signal :- fixed at a place usually semaphore type.

2- Semphore type or stop Signal :-

(Stop position)

- principle :- to show the stop position of any failure that happens to be in- apparatus.
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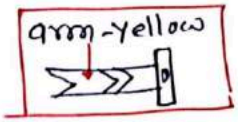
③ Warner signal :- arm - yellow



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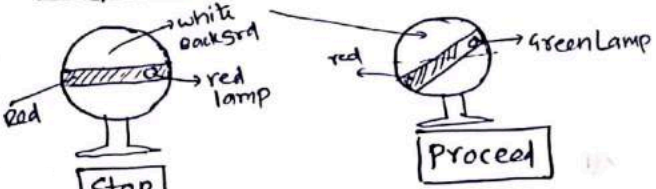
- shape → circular with red band on white backgrd.



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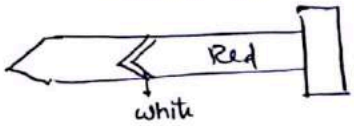

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- This adequate distance on the basis of allowable speed. BG = min 540 metir
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↳ is placed 180m beyond the trailing points & switches.
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location :- 400-500 m ahead of signal

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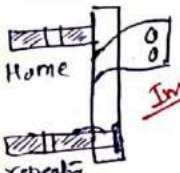

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Lotus point
24/4/2020

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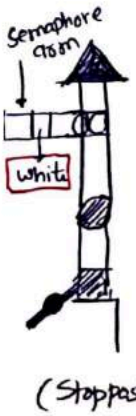

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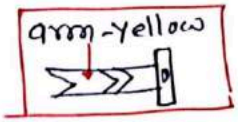

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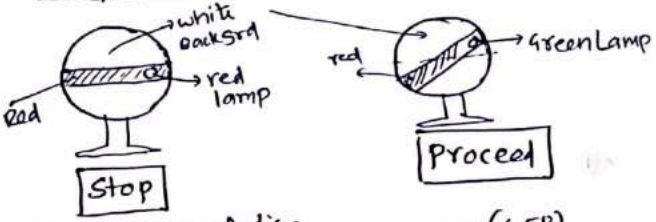

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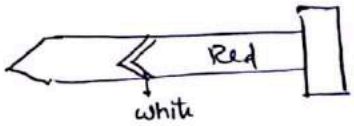

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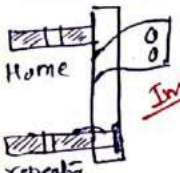

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Lotus point
24/4/2020

Points & crossing

① made by HMS (High magnese steel)

② arrangement use to move train from one track to another track.

③ Provide flexibility of movement by connecting one line to another as per requirement.

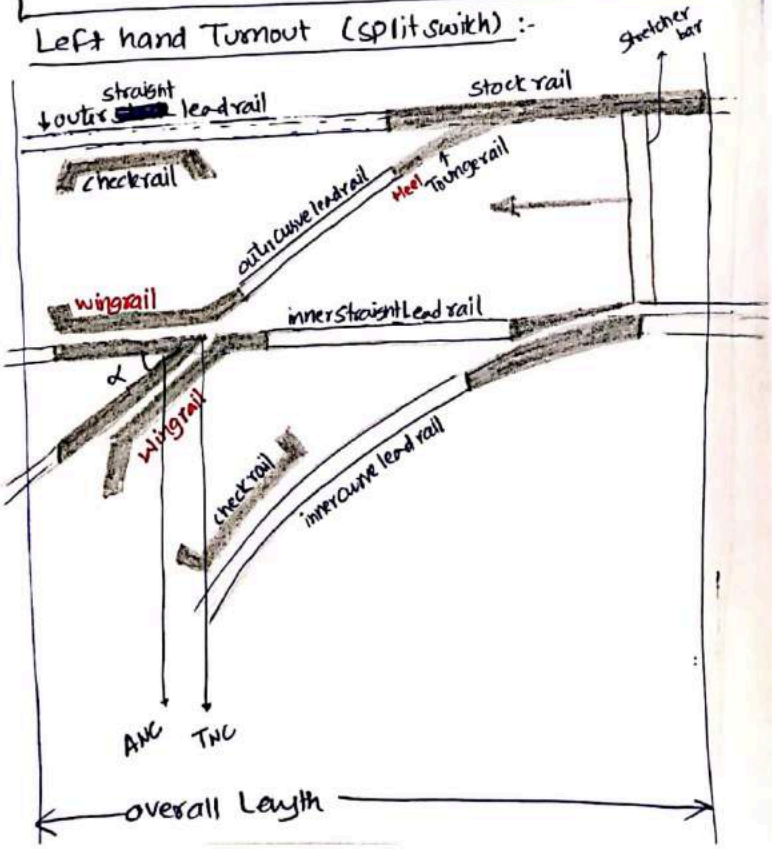
Turnout :- simplest combination of point & crossing which enables a track either branch line or siding to take off from main track.

Parts of Turnout :-

2 points or switch
2 Stock rail (1 pair stock rail)
2 check rail
a V crossing or acute angle or a crossing
4 lead rail < 2 curve lead rail, 2 straight lead rail

Studs
Bearing plate
Slide chairs
Stretcher bar
locking box
lock Bar
plunger Bar

Left hand Turnout (split switch) :-



Working principle of Turnout :

1- one turnout will provide facility to turn vehicle from one direction only (not from both the direction of turnout)

2- Turnout work with combination of point & crossing

3- point consist of
- 1 stock rail [part of outer straight lead rail]
- 1 tounge rail [part of outer curve lead rail]
- position of → 6mm higher than stock rail { so vertical wear does not exceed 6mm }

4- **Tounge rail :** It is tapered having toe at one end & heel at other end.
It is fixed at heel end and can move or rotate about this point

5- if [gap] b/w outer straight lead rail & toe of tounge rail → Then Train will pass through straight train
if [touches] → then Train divert on curve track (as shown as in Left hand Turnout figure)

6- **check rails :** (Guard rails) → introduced on curve, provided on opposite side of crossing
- Guiding one wheels of vehicle & Thus check the Tendency of other wheel to climb over crossing
- reduce wear of high rail Thus improve vehicle curve performance
- Provide parallel to inner rails on curve
- Bridge पर लगाते हैं।

7- **wing rail :** Guide the wheel path for movement of trains
- opposite to check rails
- helps in channelising the wheels in their proper route and directions means for their movement.

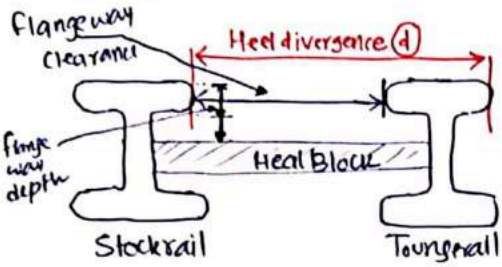
correct sequence from facing direction :-

1- Toe of switch (movable tapered end of tounge rail) → tounge rail (2) → Lead rail (3) → Crossing (4)

Other terms :-

1- Heel divergence/clearance (d) :-
distance b/w running face of stock rail & tounge rail at heel of switch.

BG = 13·3 – 13·7 cm

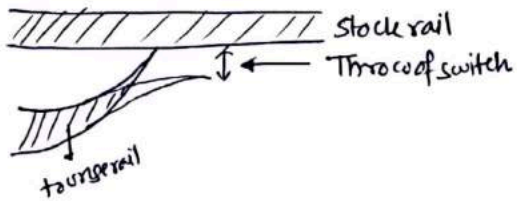


2- Flange way clearance :- distance b/w adjacent face of check rail and stock rail at heel of switch.

'or' dist. b/w the adjoining faces of the running-rail (stock rail) and the check rail near the crossing.

3- Flange way depth :- vertical distance b/w running rail (stock rail) & top of heel block.

4- Throw of switch :- (BG = 9.5cm)
max. distance by which toe of tounge rail moves sideway.



5- Switch angle α :- when tounge rail touches stock rail then —

- angle b/w running face of stock rail & tounge rail

note:- for smooth entry & movement of train (α_{min})

$\alpha \uparrow \Rightarrow$ slow moving train

$$\alpha = \frac{\text{Heel divergence}}{\text{tounge rail length}}$$

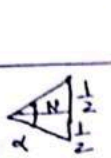
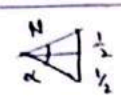
(6) - Stretcher Bar :- toe of both the tounge rail are connected together by a plate known as – Stretcher Bar.

(7) Types of switch (notused nowadays)

- Stub switch
  - no separate tounge rail
  - some portion of track is moved from side to side
- (Split switch)
  - tounge rail combined with stock rail
    - Loose heel type (Articulated type)
      - in this tounge rail joined By lead rail by fishplate
      - suit for short length switch
    - fixed heel type (flexible or spring type)
      - used with long tounge rail only
      - improvement over loose heel type.

Different methods to represent crossing angle (α)

$\alpha \downarrow \Rightarrow$ speed $\uparrow$

① Cole's method (right angle Triangle method)	 $N = \cot\alpha$ (N = no. of crossing) • used in railways	• used in railways
② centre line method	 $\tan\alpha/2 = \frac{(1/2)}{N}$	
③ Isocles Triangle method	 $\sin\alpha/2 = \frac{(1/2)}{N}$	

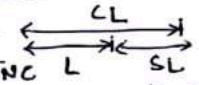
BG Vmax (kmph)	N Crossing no.	Crossing angle α	Uses
–	1 in 6	9° 27' 44"	insymmetrical split
16	1 in $8\frac{1}{2}$	6° 42' 35"	Station yard where space limited
24	1 in 12	4° 45' 44"	Station yard of main Line
–	1 in 16	3° 34' 35"	High speed Turnout on BG/MG Track

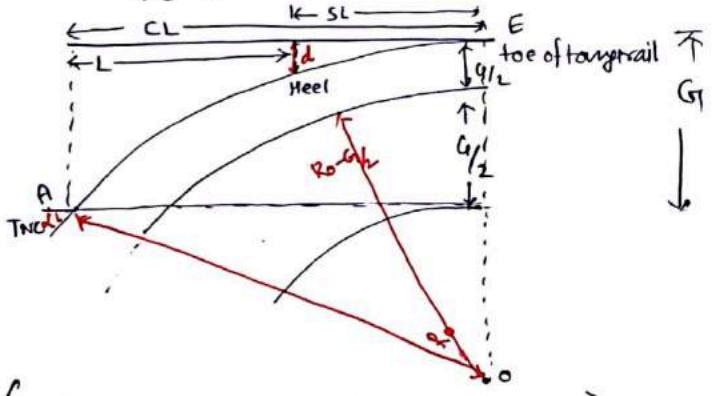
Design calculation of Turnout :

1- Curve lead (CL) :- distance measure along Stock rail b/w Toe of switch & TNC

2- Switch Lead (SL) :- distance b/w heel of switch and toe of switch measure along stock rail.

3- lead (L) :- distance b/w heel of switch & TNC

Note :-  $\boxed{CL = L + SL}$



{ outer radius $OA = OE = R_o$
central radius $R = R_o - G/2$
heel divergence 'd' = 13.3 – 13.7 BG (cm)
switch angle β crossing angle α }

case-1 :- when curve starts from toe of switch & end at TNC.

imp.

$CL = \sqrt{2R_oG} = 2GN = G\cot\alpha/2$

$R_o = 2GN^2 + 1.5G$ $\quad R = R_o - G/2$

$S_L = \sqrt{2Rd}$ $\quad CL = L + SL$

case-2. when straigh arm x given & angle of switch β given

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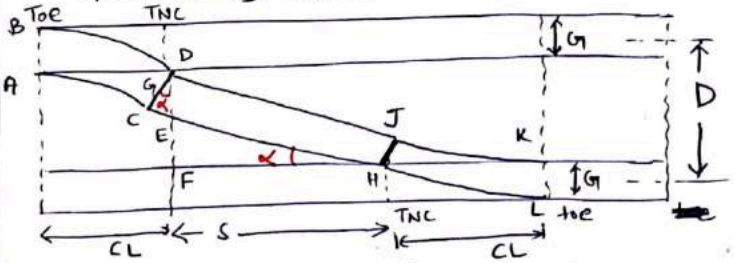

Total Length of crossover :- $CL + S + CL \rightarrow 2GN$ (L) $\quad 2GN$

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$S = \left[D - G - G\sqrt{1 + \frac{1}{N^2}}\right]N$

$S = \left[D - G - \frac{G\sqrt{1+N^2}}{N}\right]N$ $\quad$ put $\sqrt{1+N^2} \approx N$

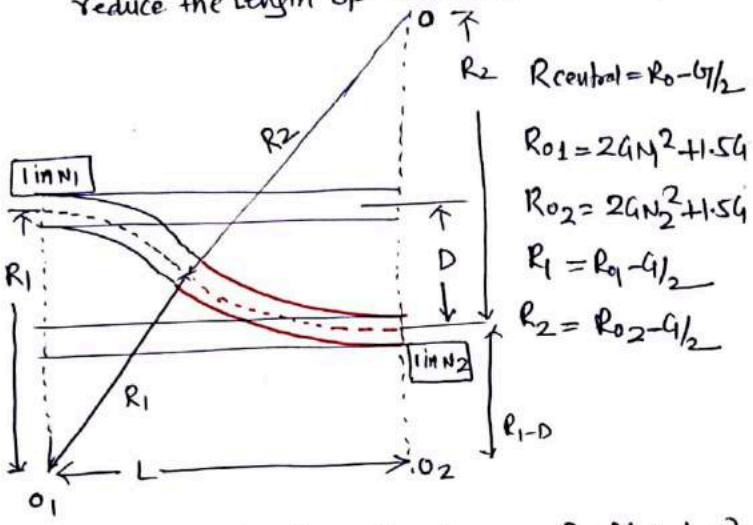
$S = DN - 2GN$ Ans.

$\therefore \boxed{L = 2GN + DN}$

(2GN = Toe, DN = S)

Type-2 :- A crossover Intermediate portion curve & crossing angle may or maynot equal

{ Basically here use of reverse curve to- reduce the Length of crossover }



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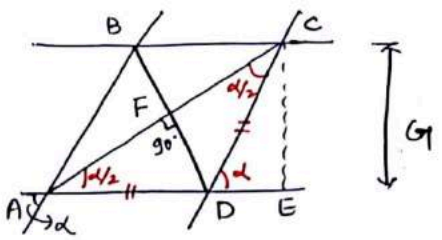

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$\sin\alpha = \frac{G}{DC}$ $\quad DC = G\operatorname{cosec}\alpha = AD = AB = BC$

② $\angle AEC$ में :- $\sin\alpha/2 = \frac{G}{AC}$ $\quad AC = G\operatorname{cosec}\alpha/2$

③ $\angle AFD$ में $\quad \tan\alpha/2 = \frac{FD}{AF} = \frac{BD/2}{AC/2}$

$\therefore BD = G\operatorname{cosec}\alpha/2 \times \tan\alpha/2$

Type-3 :- Diamond crossing :- when straight track or curved cross each other at angle less than 90° , a diamond shape formed known as diamond crossing.

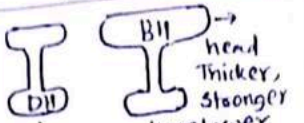
1- It can not transfer rails from one track to another track.

2- It consist → 2 acute angle crossing + 2 obtuse " → 4 check rails

3- In Indian railways :
flattest diamond to be 1 in 10 BG, 1 in $8\frac{1}{2}$ MG/NG

4- avoided because it reduces speed.

5- Length of Gap b/w 2 noses of an obtuse crossing increases as the acute Angle of crossing decreases.

Parameter	Vignole's rails or Flat footed rails (FF)	Bull headed rails (BH) & double headed rails (DH)
Cross-section	 52 MR (52 kg/m) upto 130 kmph; 60 MR (60 kg/m) upto 160 kmph	 पहले यह लगाते थे परन्तु अब नहीं लेकिन पहले ही रखवा दी गयी
Strength & Stiffness	for same weight more	for same weight less
laying & relaying	simple	Difficult
initial cost	∵ fastner less & cost less thus initial cost Less	∵ fastner more & costly hence initial cost hight
M&R cost	Less	more

Defect on rails :

① Corrugated or roaring rail

- consist of minute depression on surface of rail
- created where either breaks are applied or train start
- when train passes over it - roaring sound occures

Solution → Grinding the rail head

② Kinks or Shoulders

- when ends of adjoining rails, moves slightly out of position kink formed.

Solution * By correcting alignment at joint and at cusved locations.
* proper packing of joints
* Proper maintenance of track Periodically in respect of cross-level, gauge, alignment, welding of worn out portion.

③ Hogged rails

- due to battering action (repeated hitting or impact action of wheel at the end of rail, the rails get bent down and get deflected at ends.

Solution : ① Dehogging ② welding ③ replacing ④ cropping

- occures due to loose packing of ballast, loose fish plate at joints.

④ Buckling of rail

- if sufficient gap / expansion joint is not available, the thermal expansion will not accomodate within the expansion joint which will - Create thermal stresses in rails, rail will buckle.
- Buckling also occures if fish plate - are bolted so tighly that rails are not allowed to slip or expand.

Solution :- ① Lubrication
② fish plate not too tight
③ Expansion Gap.

⑤ Scabbing of rails

- due to falling of patches, chunks of metal from rail table.
- Shape → elliptical depression, whose surface reveals a progressive fracture with numerous cracks around it

⑥ Wheel burns

- cause by slipping of driving wheel of Loco. on rail surface, due to this extra heat generated and - surface of rail gets affected, resulting in depression on the rail table
- wheel burn are generally noticed on - Steep gradient or there are heavy - incidence of braking or near water column

⑦ Shelling and blackspots

- Progressive horizontal separation of metal that occures on gauge side generally at upper Gauge corner.
- cause due to heavy bearing pressure on a small area of contact, which - Produces heavy internal shear stress.

Important Test on rails :- to determine servireability of rail section

1- falling weight Test	done at every cast of 100 metric ton
2- Tensile Strength Test	min = 72 kg/mm²
3- Hammer Test	

compulsory Test

① fish plate :- connect one rail to another rail (to maintain continuity of joint)

② sleeper :- ↓↓ • transfer point load into udl load
• maintain gauge

③ Ballast – • line load to udl load transfer
• Provide some elasticity to track

④ Rails :- converts rolling loads of wheel into – Points Load and transfer it to sleeper.

⑤ Track modulus :- Based on elastic theory
• index for stiffness / resistance of permanent way
• ratio of $\frac{\text{load}}{\text{unit length}}$ of rail, to produce unit depression in sleeper.

⑥ fastening → to fix rail with sleeper directly.

⑦ tie bar → fix rail to CI sleeper through a plate

⑧ crossing → at intersection of 2 rails

⑨ spikes :- to hold rail on wooden sleeper

⑩ chair :- used to support BH rails on sleepers

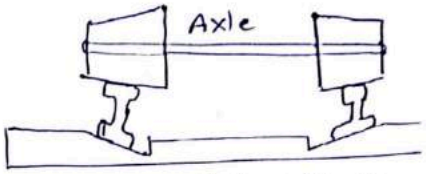
⑪ Bolts :- Dog / hook bolts where sleeper directly rest over steel girders.

⑫ keys :- Small tapered piece of Timber, coated on steel, used to fix rails to chairs on – metal sleepers.

⑬ Bearing plate :- used below FH rails to distribute the load on large area.

coning of wheels :- The distance b/w inside – edge of wheel flange is kept less than Gauge of track.

• wheel is coned to keep it in central position automatically, these wheels are coned at slope of 1 in 20.



• Advantages :-

1 – to reduce wear and tear of wheel flange and rail (which is due to rubbing action of flanges with inside faces of rail head.

2 – to provide possibility of lateral movement of axle with its wheel.

3 – to prevent the wheels from slipping to some extent

Adzing of sleeper or tilting of sleeper :-

• for effective use of coning of wheels, the rails are not laid at horizontal, they are laid at a slope of 1:20 on sleepers

creep of rail :- longitudinal movement of rail wrt sleeper in track.

Creep theory → wave action Theory
→ Percussion "
→ Drag theory

causes of creep :- (i) rails not secured properly to sleepers
(ii) Inadequate Blast resistance
(iii) Badly maintained rail joints
(iv) Improper expansion Gap
(v) Lack of proper drainage
(vi) loose / uneven packing

effect of creep :- 1 – Buckling of track
2 – disturb Gauge & alignment of track
3 – points & crossing gets distorted.

measurement of creep :- in 3 months interval
{BG max = 150mm creep}

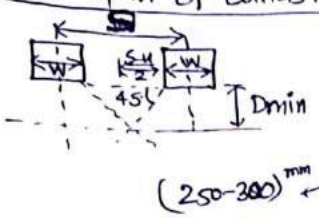
Composite sleeper Index (CSI):-

- measure mechanical strength of Timber
- derive from its composite property (strength (S), hardness (H))

$$CSI = \frac{S+10H}{20}$$

S → strength index
H → hardness index
@ 12% M.C

min. depth of Ballast section :-



$$\tan 45 = \frac{(S-W)/2}{D_{min}}$$

$$D_{min} = \frac{S-W}{2}$$

$(250-300)^{mm}$

S = c/c dist b/w sleepers or sleeper spacing
W = width of sleeper

Survey work for Track Alignment :-

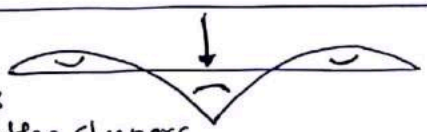
1- Traffic survey
2- Recannissance
3- Preliminary survey
4- Detailed / Location survey

sleeper density :- no. of sleepers in rail Length

{ BG = 13m
MG = 12m }

(M + x) → 3 to 7
↓
12-13

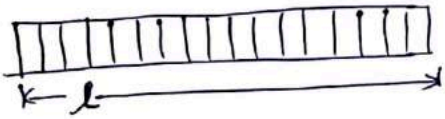
stresses on rail :-



- rail acts continuous beam carried on to the sleepers which provide elastic support

Length of welded rail :-

L → Length of rail



α ✓
T ✓
E ✓

- if expansion not allowed, thermal stress developed = $\alpha T E$

∴ Thermal force developed = $(\alpha T E)A$

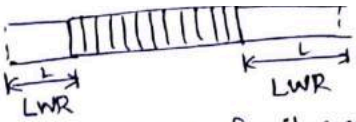
This internal force (f_s) resisted by sleeper.

Let resisting force per sleeper ⇒ R

∴ no. of sleepers (n) = $\frac{(\alpha T E)A}{R}$

∴ Length of welded rail = $(n-1)S$

Breathing Length :-



incase of LWR, the min. length of rail required to be welded at the end of track, so the portion of rail b/w welded rail does not undergo any thermal expansion / contraction is known as breathing Length.

breathing Length at both ends = $(n-1)S$

∴ total Breathing Length = $2(n-1)S$