A LECTURE NOTES ON

PERMANENT WAY

COURSE MODULE-INDUCTION COURSE – INITIAL SSE/JE

Course No. CE 26 **Module No. 26.5**

SUB: P.WAY, ESTABLISHMENT, ACCOUNTS, STORES & RAJBHASHA

Duration: 74 Sessions = 148 Periods

Sub-discipline	Lesson	Session wise Contents
Track Technology Lessons: 15 Sessions: 47	Lesson-I: Introduction to Railway Organization.	Session-1: History of Railways, Zonal Railways, Divisions, Production units.
		Session-2: TT Organization on Indian railways, Organization at headquarters and Divisional levels, CPOH and Bridge Workshop.
	Lesson-II: Railway Track	Session-3: Constituents of Railway Track. Requirements of Good Railway Track, Classification of Routes. Different Gauges.
	Lesson-III: Formation	Session-4: Formations in Embankment and Cutting.
	Lesson-IV: Rails	Session-5: Functions, Types & Standard Rail Section.
		Session-6: Standard length, Rolling marks & UTS.
	Lesson-V: Sleepers	Session-7: Functions, Types & Sleeper Density.
		Session-8: Requirements of PRC sleepers-their advantages and disadvantages.
	Lesson-VI: Fastenings	Session-9: Rail to Rail fastenings.
		Session-10: Rail to Sleeper fastenings.
	Lesson-VII: Ballast	Session-11: Functions & Specifications.
	Lesson-VIII: Points & Crossings	Session-12: Functions & Important terminology.
		Session-13: Constituents of Turnout.
		Session-14: Types of switches.
		Session-15: Switch Angle, Flange way clearance, Heel divergence, Throw of switch.
		Session-16: Types of Crossings, Crossing number & Main constituents of Built-up Crossing.
		Session-17: Standard Turnouts & permissible speed.
		Session-18: Position of Sleepers at Points & Xing
		Session-19: Yard Visit

	Lesson-IX: Welding of Rails	Session-20: Evil effects of Rail joints.
		Session-21: Different types of welding.
		Session-22: Development of Welded rails.
		Session-23: Welding Terminology.
		Session-24: Theory of Welded rails.
		Session-25: Thermal forces in LWR.
		Session-26: Permitted locations of LWR/CWR.
		Session-27: Different Temperature Zones.
		Session-28: De-stressing
		Session-29: Yard visit
	Lesson-X: Track Renewals	Session-30: Classification of Track Renewals.
		Session-31: Factors governing Renewals.
	Lesson-XI: Maintenance of Track	Session-32: General Instructions as contained in IRPWM.
		Session-33: Provisions on Regular Track Maintenance as contained in IRPWM.
		Session-34: Provisions on Works incidental to Regular Track Maintenance with thrust on Deep Screening.
		Session-35: Provisions on Maintenance of Track in Track Circuited Areas as contained in IRPWM.
		Session-36: Provisions on Maintenance of Track in Electrified Areas as contained in IRPWM & Precautions during Machine working.
	Lesson-XII: Engineering Restrictions & Indicators	Session-37:Categorioes of Engineering Works, Engineering Fixed Signals/Indicators: Temporary and Permanent
		Session-38: Emergency Protection of track: Single Line & Double Line, Detonators & Flare Signals.
	Lesson-XIII: Curves	Session-39: Necessity of curves: their types, TTP, CTP & Transition lengths.
		Session-40: Radius, Degree, Versine & Field Measurement.
		Session-41: Super-elevation: Cant deficiency, Cant excess, Cant gradient, Equilibrium cant.
		Session-42: Negative Super-elevation, Gauge widening.
		Session-43: Safe Speed on Curves.
		Session-44: Yard visit.
	Lesson-XIV: Track Tolerances	Session-45: Different Track Parameters and their service tolerances.
		Session-46: Different Track Parameters and their service tolerances.

	Lesson-XV: Schedule of Dimensions	Session-47: Different Schedules, Standard Dimensions, Loading Gauge, ODC.
Establishment Lessons: 13 Sessions: 14	Lesson-XVI: Leave Rules	Session-48: Various types of Leaves, Eligibility etc.
	Lesson-XVII: Pass Rules	Session-49: Various types of passes, Eligibility etc.
	Lesson- XVIII: P.L. Bonus & GIS	Session-50: Terms of Payments PLB, GIS Monthly subscription, Payment at retirement.
	Lesson-XIX: Allowances & Overtime	Session-51: Various Types of Allowances & Eligibility
	Lesson-XX: P.F.	Session-52: Meaning, Rate, Withdrawal.
	Lesson-XXI: Pension Rules	Session-53: Pension Rules.
	Lesson-XXII: DCRG	Session-54: Amount of DCRG, Emoluments.
	Lesson-XXIII: D&A Rules	Session-55: Minor Penalties.
		Session-56: Major Penalties.
	Lesson-XXIV: Service Conduct Rules	Session-57: Explanation and understanding of different Conduct rules.
	Lesson-XXV:	Session-58: Manpower Planning & Training Welfare Measures in Railways, PNM, JCM & PREM.
	Lesson-XXVI: Objectives and understanding of Various Acts	Session-59: Minimum Wages Act, Factory Act, Industrial Dispute Act, Contractor Labour Act& Workmen Compensation Act.
	Lesson-XXVII: HOER	Session-60: Classification and Duty roster.
	Lesson–XXVIII: Awards	Session-61: Different Awards.
Accounts Lessons: 3 Sessions: 6	Lesson–XXIX: Estimates	Session-62: Definition & Necessity of Estimates.
		Session-63: Kinds of Estimates & their Vetting.
	Lesson-XXX: Tenders	Session-64: Different types of tenders.
		Session-65: Power for Invitation of tenders & NIT.
	Lesson-XXXI: Railway Budget	Session-66: Parliamentary Control over Railway Finance, Public Accountability, Canons of financial Propriety.
		Session-67: Railway Budget, Budgetary Terms, Budgetary Cycle, Demand of Grants, Expenditure classification, Works Programme.

Store Lessons: 1 Sessions: 3	Lesson-XXXII: Introduction to Engg. Stores& Inventory Control	Session-68: Stock heads of Accounts, Disposal of released and surplus materials.
		Session-69: Indenting procedure, Issue note and Write-off statement.
		Session-70: Stock verification and Inventory Control Technique.
Medical Awareness Programme Lessons: 1 Sessions: 2	Lesson-XXXIII: Medical Awareness Programme	Session-71: Family Welfare, AIDS, Family Management & First Aid.
		Session-72: Stress Management & Disaster Management.
Rajbhasha Lessons: 1 Sessions: 2	Lesson-XXXIV: Rajbhasha	Session-73: Constitutional Provisions, Official Language Act 1963, Official Language Rules 1976.
		Session-74: Policy Guidelines & Instructions.

History of Railways and General Features

History of Railways:

The history of railways is closely linked with the growth of civilization of mankind. In 15th century stone slabs or wooden baulks were laid flush with the road surface for carriage of heavy goods loaded on carts and drawn by animal. These were called "Tram ways'. These Tram ways were extensively used in 16th century in mines in central Europe for carriage of coal and other minerals.

The timber bulks were replaced by iron plates to reduce wear and these were called 'Plate ways'. These iron plates were also substituted in course of time by angle irons to give lateral support or better safety. The present railway track is a gradual evolution from these 'Plate ways.'

The first public railway in the world was opened to traffic on 27th September, 1825, when the first train made its maiden journey between Stockton and Darlington in U.K.

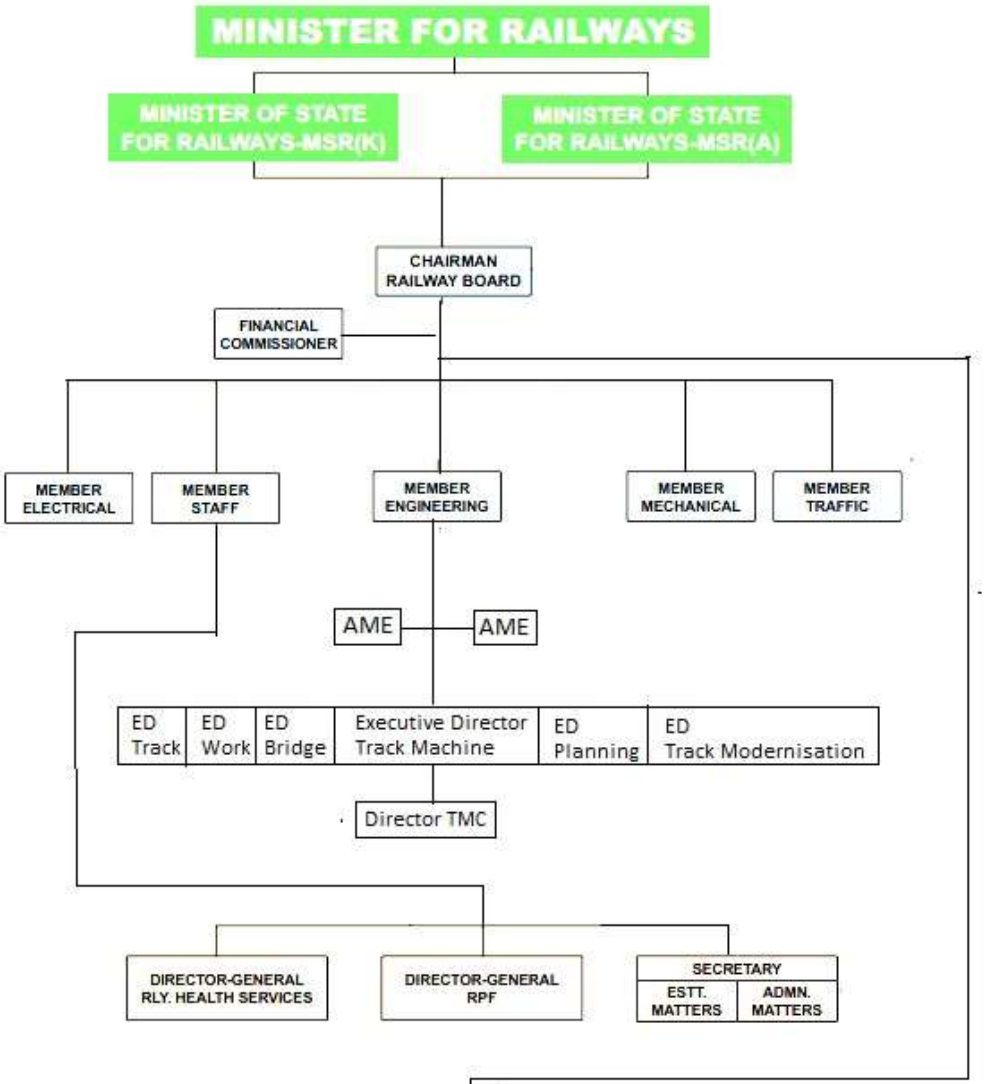
The maiden trip on Indian Soil of the first train consisting of one steam engine and 4 coaches was made on 16th April 1853, when it traversed a 21 mile stretch between Bombay and Thana in 1.25 hour time. Starting from this humble beginning, the Indian railways system has grown up today into a giant network consisting of 65000 route Kms.

The Indian Railways run about 13,000 trains every day, serving about 8000 railway stations and carry about 5112 million passengers and about 581 million tonnes of goods traffic in a year. For moving this traffic, the Indian Railways deploy about 15, 40, 000 (15.40lakh) employees and maintain 7,817 locomotives consisting.

Railway Board:

The responsibility of the administration and management of the Indian Railways rests with the Railway Board under the overall supervision of the minister for railways. The Railway Board consists of Chairman, financial commissioner for railways and five other functional members.

The other members of the railway Board are separately incharge of matters relating to staff, Civil Engg., Traffic, Mechanical Engg. & Electrical Engg. They function as ex-officio secretaries to the Government of India. The board members are assisted by additional members, executive directors & directors. The organization chart is as below:



ZONAL RAILWAYS (OPEN LINE)	PRODUCTION UNITS	OTHER UNITS	PUBLIC SECTOR UNDERTAKINGS/ CORPORATIONS, ETC.
GENERAL MANAGERS	GENERAL MANAGERS	GENERAL MANAGERS	BCL
CENTRAL	CHITTARANJAN LOCOMOTIVE WORKS	CENTRAL ORGANISATION FOR RAILWAY ELECTRIFICATON	BSCL
EASTERN	DIESEL LOCOMOTIVE WORKS	NF RAILWAY (CONSTRUCTION)	BWEL
EAST CENTRAL	INTEGRAL COACH FACTORY	CAO (R) *	CONCOR
EAST COAST	RAIL COACH FACTORY	CENTRAL ORGANISATION FOR MODERNISATION OF WORKSHOPS	CRIS
METRO **	RAIL WHEEL FACTORY	INDIAN RAILWAY PROJECT MANAGEMENT UNIT (IRPMU)	DFCCIL
NORTHERN	CAO (R) *	INDIAN RAILWAY ORGANISATION FOR ALTERNATE FUELS (IROAF)	IRCON
NORTH CENTRAL	DIESEL LOCO MODERNISATION WORKS	DIRECTOR-GENERAL	IRCTC
NORTH EASTERN		RAILWAY STAFF COLLEGE	IRFC
NORTHEAST FRONTIER		DIRECTOR-GENERAL & EX-OFFICIO GENERAL MANAGER	KRCL
NORTH WESTERN		RDSO	MRVC
SOUTHERN			RCIL
SOUTH CENTRAL			RITES
SOUTH EASTERN			RLDA
SOUTH EAST CENTRAL			RVNL
SOUTH WESTERN			
WESTERN			
WEST CENTRAL			

** Metro Railway, Kolkata. * Chief Administrative Officer (Railways). (As on 28th January, 2013)

Zonal Railways details & Divisions:

The entire railway system has been divided into 17 zones. Zonal Railways work on divisional system. Each division has around 800 to 1500kms of track. There are 68 divisions on Indian railways. Each division works under the overall Control of Divisional Railway Manager (DRM) who is assisted by ADRM. In Engineering the division is headed by Sr. Divisional Engineer(C) and he is assisted by Sr.DEN/DENs. Each Sr. DEN/DEN is incharge of around 1100 ITKM & has 2-3 ADENS to assist him in maintenance of P. Way & Works. The details of zones and zonewise break up of divisions over Indian Railways are listed as below:

SNo	Name	Abbreviation	Date Established	Headquarters	Divisions
1.	Central	CR	5 November 1951	Mumbai	Mumbai, Bhusawal, Pune, Solapur, Nagpur
2.	East Central	ECR	1 October 2002	Hajipur	Danapur, Dhanbad, Mughalsarai, Samastipur, Sonpur
3.	East Coast	ECoR	1 April 2003	Bhubaneswar	Khurda Road, Sambalpur and Waltair (Visakhapatnam)
4.	Eastern	ER	April 1952	Kolkata(Fairle Place)	Howrah, Sealdah, Asansol, Malda
5.	North Central	NCR	1 April 2003	Allahabad	Allahabad, Agra, Jhansi
6.	North Eastern	NER	1952	Gorakhpur	Izzatnagar, Lucknow, Varanasi
7.	North Western	NWR	1 October 2002	Jaipur	Jaipur, Ajmer, Bikaner, Jodhpur
8.	Northeast Frontier	NFR	15 January 1958	Guwahati	Alipurduar, Katihar, Rangia, Lumding, Tinsukia
9.	Northern	NR	14 April 1952	Delhi	Delhi, Ambala, Firozpur, Lucknow, Moradabad
10.	South Central	SCR	2 October 1966	Secunderabad	Vijayawada, Hyderabad, Guntakal, Guntur, Nanded, Secunderabad
11.	South East Central	SECR	1 April 2003	Bilaspur	Bilaspur, Raipur, Nagpur

12.	South Eastern	SER	1955	Kolkata(Garden Reach)	Adra, Chakradharpur, Kharagpur, Ranchi
13.	South Western	SWR	1 April 2003	Hubli	Hubli, Bangalore, Mysore
14.	Southern	SR	14 April 1951	Chennai	Chennai, Trichy, Madurai, Salem,[Palakkad, Thiruvananthapuram
15.	West Central	WCR	1 April 2003	Jabalpur	Jabalpur, Bhopal, Kota
16.	Western	WR	5 November 1951	Mumbai	Mumbai Central, Ratlam, Ahmedabad, Rajkot, Bhavnagar, Vadodara
17.	Kolkata Metro Railway	KMR	29 December 2010	Chitpur(Kolkata)	Kolkata metropolitan area, South 24 Parganas, North 24 Parganas

Production Units:

Apart from Zonal Railways there are seven production units as given below:

S. No.	Name of Unit	Headquarters	Establishment Year	Functions
1.	Chittranjan Locomotive Works (CLW)	Chittranjan	1947	Manufacture of Electric Locomotives
2.	Diesel Locomotive Works (DLW)	Varanasi	1961	Manufacture of Diesel Locomotives.
3.	Integral Coach Factory (ICF)	Parambur	1952	Manufacture of Coaches
4	Diesel Component Works (DCW)	Patiala	1981	Manufacture of Diesel components
5	Rail Coach Factory (RCF)	Kapurthala	1986	Manufacture of Coaches
6.	Wheel& Axle Plant (W&AP)	Bangalore	1984	Manufacture of Wheel & Axles
7.	Rail Coach Factory(RCF)	Rae-Bareli	2012	Manufacture of Coaches

Summary:

History of Railways:

Railway history is closely linked with the growth of civilization of mankind.

Growth of Railways:

- *In 15th century stone slabs or wooden baulks were laid flush with the road surface for carriage*
- *of heavy goods loaded on carts and drawn by animal. These were called "Tram ways'.*
- *These Tram ways were extensively used in 16th century in mines in central Europe for carriage of coal and other minerals.*
- *The timber bulks were replaced by iron plates to reduce wear and these were called 'Plate ways'. These iron plates were also substituted in course of time by angle irons to give lateral support or better safety.*
- *The present railway track is a gradual evolution from these 'Plate ways.'*

Public Railway Service

- *The first public railway in the world was opened to traffic on* ***27th September, 1825****, when the first train made its maiden journey between* ***Stockton and Darlington in U.K.***

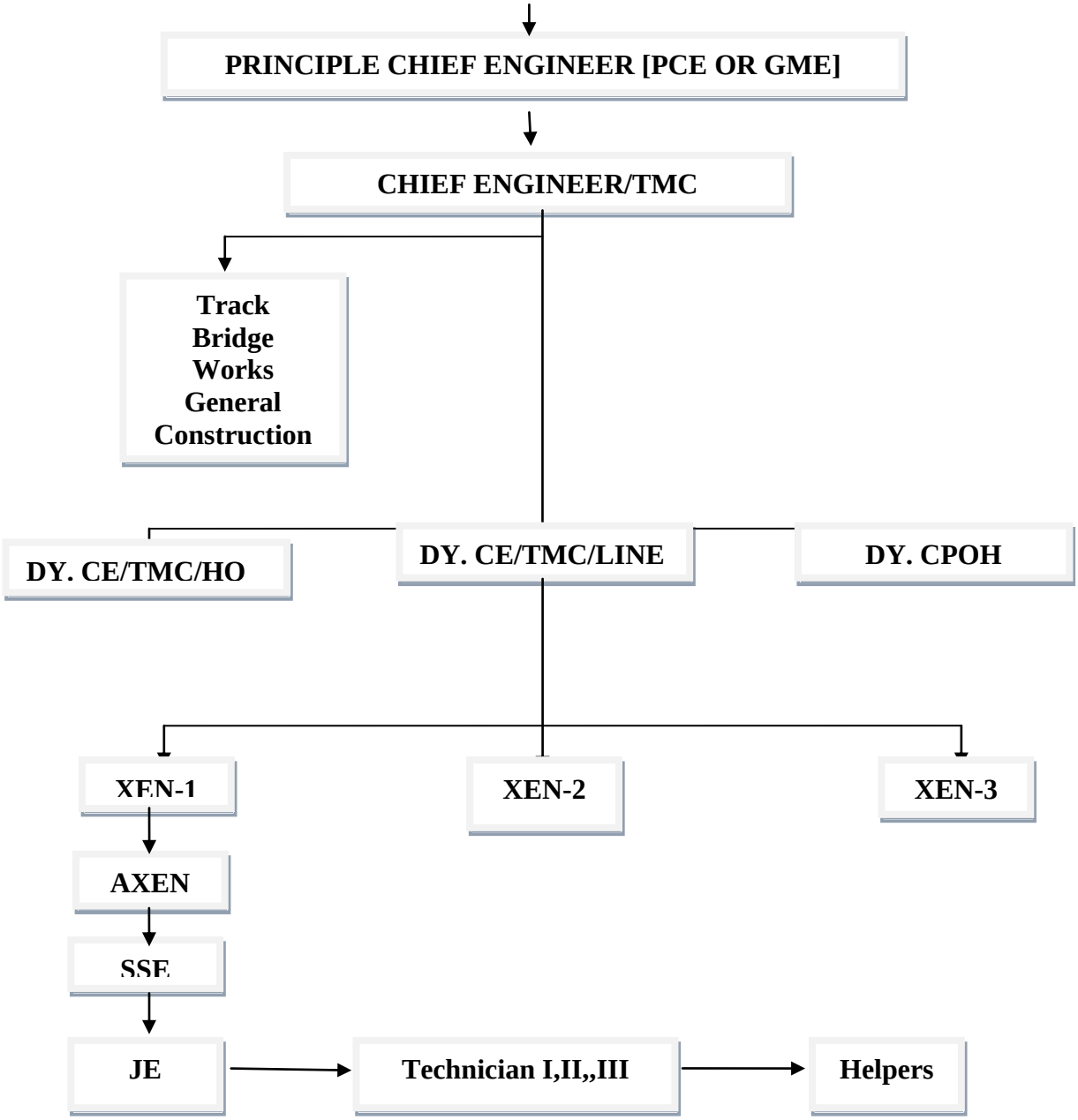
First Rail Trip in India

- *The first train consisting of one steam engine and 4 coaches made its debut run on* ***16th April 1853****, for a Stretch of* ***21 miles (33.796 Kms) between Bombay and Thana in 1.25 hours time****.*

Indian Railway Facts Today

- *Total Route Km's Available with Indian Railway's:-* ***65000 route Kms of which 16500 Km's are Electrified.***
- *Trains Running Every Day :-* ***13.000 trains every day of Which 7031 are Passenger Trains***
- *Number of Railway Stations Available :* ***8000 railway stations***
- *Approx Number of Passengers Carried:-* ***5112 million/Year or 14.01 Million/Day***
- *Approx Limit of Goods Carried in the Traffic Year :-* ***581 million tones***
- *Staffs Employed in Indian Railways :* ***15.40 Lakhs-(1.54 Million)***
- *Total No of Locomotives Present with The IR :* ***7817 Locomotives****.*

Zonal Railway Organization Chart for Track Machine Department:



TT Organization on Indian Railways

The organization shall be under the overall charge of Chief Track Engineer (Machines) of the Railway who shall be reporting to the Chief Engineer through Chief Track Engineer. The organization shall be responsible for the following functions:

i. Field operation of track machines,
ii. Repair and maintenance of machines,
iii. Supervision and technical services including training, and
iv. Planning and deployment of machines.

To carry out each of the above functions, chief Track Engineer (Machine) shall be assisted by one or more Deputy CE (Machine). It is already shown in the previous organizational chart.

DUTIES OF AEN:

GENERAL:
The Assistant Engineer is responsible for maintenance and efficient working of all the track machines in his charge.

IMPORTANT DUTIES:
- Inspection and maintenance of all machines.
- Ensure adherence to stipulated maintenance schedules.
- Ensure availability of necessary staff for operation.
- Ensure achievement of stipulated target.
- Ensure adequate availability of consumables and spares.
- Initiate proposals and plans for major schedule of work.
- Ensure co-ordination with other units of engineering department.
- Verification of store.
- Ensure maintenance of various records.
- Ensure availability of tools.

TRAINING OF PROBATIONERS
STAFF MATTERS
All the section engineers and other staff working under him receive proper training in maintenance practice.
Service and leave records
Witnessing payments to staffs
Knowledge of rule & regulation
Inspection by higher officers

INSPECTION OF MACHINE BY ASSISTANT ENGINEER
- Inspection of machines by the Assistant Engineer shall be carried out in detail covering necessarily the following aspects and keep in view the Check List Maintenance Schedule issued by RDSO.
- Health of engine.
- Condition of hydraulic, pneumatic, electrical and electronic systems.
- Condition of transmission/brake system.
- Performance of the machine.
- Staff accommodation.
- Availability of the spares with the machine.

EXECUTION OF WORKS

DUTIES OF (SENIOR) SECTION ENGINEER/TMC:

i. The (senior) Section Engineer/Track Machines shall be responsible for the satisfactory operation, maintenance and productivity of the machines under his charge and quality of work.
ii. He shall be well acquainted with the working systems, operating instructions, maintenance schedules, specifications of the oils/lubricants to be used, critical components etc of machines under his charge.
iii. He shall have thorough knowledge of the rules and regulations and procedures concerning his work and duties as laid down in this Manual, G&S Rules, IRPWM, Engineering Code and other departmental codes, extant orders and circulars issued from time to time.
iv. He shall have in his possession up-to-date copies of the rule books/documents/manuals pertaining to the safe, efficient and trouble-free working of the machines and also other codes and books applicable and needed for the day-to-day working.
v. He shall maintain the records pertaining to the machines under his charge and submit the prescribed returns regularly.
vi. He shall ensure discipline among the staff working under his within the framework of rules and endeavor to keep their moral high and look after their welfare.
vii. He shall ensure proper handing over/taking over of the charge when transfer/change of portfolio is affected.
viii. He shall plan and ensure timely execution of the maintenance schedules of the machines within the specified time.
ix. He shall keep himself abreast of the various methods and techniques of reconditioning of components and availability status of spares at the Base Depot for efficient re-commissioning of the machine during breakdowns.
x. He shall investigate major failure of the machine critically for corrective actions/remedial measures and for fixing responsibilities in case of failures occurring due to lapses of staff.
xi. He shall be conversant with the provisions in various Service Agreement/Contracts and organize the visits of Service Engineers (scheduled or breakdown).

DUTIES OF MACHINE OPERATORS:

Each machine shall be under the direct charge of Section Engineer/Junior Engineer hereinafter called the operator. He shall ensure the following:

i. Operation and maintenance of the machine.
ii. Carrying out pre-block maintenance and making the machine fit for working.
iii. Initial setting out for the block working and closing the work of the machine including ramping in/ramping out of general lift to the track as in case of tie-tamping machine.
iv. Proper functioning of all the systems and components and keeping a watch on the controls/indicators/gauges.

v. Taking precautions for special Design Mode operations such as curve slewing etc in case of tamping machine.
vi. Posting of fitters/khalasis at respective places around the machine for monitoring the work of various systems, carrying out during block maintenance (greasing, oiling, tightening of bolts etc.) and also to attract attention of the main cabin Operator and assist him in the event of any problem of malfunctioning of the machine or due to track obstructions.
vii. He shall ensure safe working of the machine and staff. When there are more than one Operator on the machine, the senior-most Operator shall be the Machine In-charge. In addition to his normal work as an Operator he shall be responsible for the following functions in which he will be assisted by other Operators/staffs:

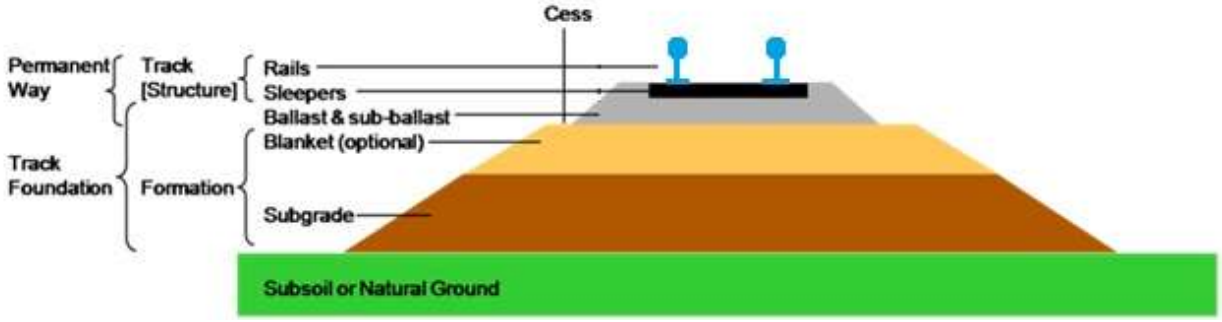
i. Carrying out the prescribed schedule of maintenance and keeping proper records of the same.
ii. Safe custody, account and replacement of the spares, Tools & Plants and consumables issued for the machine and returning of released spares to base depot for reclamation/condemnation.
iii. Keeping systems of the machine in working condition and ensuring the target output, duly maintaining quality.
iv. Maintaining log books and other records, sending daily and other periodical reports/statements using appropriate fastest mode of communication.
v. Liaisoning with the Divisional Officials for efficient working of his unit, coordination with the Permanent Way staff and planning daily programme of machine work and interacting with the Permanent Way staff for working in design mode, slewing of curve etc.
vi. Actively associating during visit of firm's Service Engineer, furnishing of such information as may be needed for proper examination of the machine and taking necessary follow up action.

DUTIES OF TECHNICIAN:

The main functions of Track Machine Fitters/Mechanics are:

i. To attend to the daily and weekly maintenance schedules of machine and record the compliance in log book.
ii. To extend help during other maintenance schedules/service checks by the Service Engineers.
iii. To keep in his custody the various tools and equipment necessary to attend repairs and ensure their working condition.
iv. To remain vigilant during movement and working of machine and to inform the operator of any abnormalities.
v. To guide and supervise the semi-skilled/unskilled staff in attending to the maintenance/repairs.
vi. To ensure safety of the machine and men from approaching trains on adjacent lines.
vii. Any other work assigned to him by the machine in-charge.

1. TRACK:



It is a rail road on which the train runs.

It is also called permanent way. It basically consists of two parallel rails having specified distance in between them and fastened to sleepers which are embedded in the layer of ballast, which is spread over formation.

Rail are joined to each other longitudinally by fish plates by end to end and fastened to sleeper by various fittings. Sleepers are placed at a specified distance and are held in position by embedding in the ballast.

Track Gauge:

The perpendicular distance between inner faces of rail is called gauge. It is measured 13mm below from rail top. The Indian Railways operate in three different gauges mainly Broad Gauge (1676mm), Meter Gauge (1000mm), and Narrow Gauge (762mm & 610mm) wide. The broad gauge accounts for nearly 75% followed by meter gauge 24% of the total route length. The gauge of track in India is measured as the minimum horizontal distance between the running or gauge faces of two rails 14mm below from top of rail. The standard gauge is 1435mm

DIFFERENT GAUGES ON INDIAN RAILWAY:

(i) B.G. (broad gauges) : - 1676 mm
(ii) M.G.(Meter gauges) :- 1000 mm
(iii) N.G. (Narrow gauges):- 762 mm
(iv) Special Narrow Gauge:- 610 mm
(v) Standard Gauge :- 1435 mm (Foreign Railways)

2. COMPONENTS OF TRACK:

Following are the main components of the track:-

(1) Rails
(2) Sleepers
(3) Fitting & Fastenings
(4) Ballast
(5) Formation

3. REQUIREMENT OF GOOD TRACK:

A permanent way or track should give comfortable & safe ride at maximum permissible speed with minimum cost. For achieving the above objectives a good permanent way should have the following characteristics:-

(i) The gauge should be correct and uniform.
(ii) The rail should have uniform and perfect cross-level.
On curve outer rail should have proper super – elevation to take an account of the centrifugal force.
(iii) The alignment should be straight and free of kinks. In case of curve proper transitioning should be provided between straight and curve to give smooth ride.
(iv) The gradient should be uniform and as gentle as possible. The change of gradient should be followed by proper vertical curve.
(v) The track should be resilient and elastics in order to absorb shocks and vibrations of running trains.
(vi) The track should have good drainage so that the stability of the track is not affected due to water logging.
(vii) The track should have good lateral strength, so that it can maintain its stability due to variation of temperature and other factors.

(viii) There should be provision for easy replacement and renewals of various track components.
(ix) The laying & Maintenance cost of track should be low.
(x) It should be antitheft type & shall be free from sabotage.

CLASSIFICATION OF ROUTES:

Broad Gauge Routes:
All the B.G. routes of Indian Railways have been classified based on speed criteria as given below:

(A) Group 'A' Lines:
These are meant for a sanctioned speed of 160 KMPH. In this category, the following lines fall:

1. New Delhi – Howrah – by Rajdhani Exp. Route.
2. New Delhi – Bombay – By Frontier Main or Rajdhani Route.
3. New Delhi – Chennai Central – By Grant Trunk Route.
4. Howrah – Mumbai VT - via Nagpur.

(B) Group 'B' Lines:
These are meant for a sanctioned speed of 130 KMPH .

(C) Group 'C' Liens:
These include suburban section of Mumbai, Delhi ,Chennai and Kolkota

(D) Group 'D' special:
Section where traffic density is very high or likely to grow substantially in future and sanctioned speed is 100 Kmph at present.
Group 'D' Lines:
Sections where Max^{m} speed is100 Kmph.

(E) Group 'E' Special:
Sections where traffic density is very high or likely to grow substantially in future and at present the max^{m}. Sanction speed isles than 100 Kmph.
Group 'E' Lines:
These includes other sections and Branch line.

Classfication of M.G. Routes

Depending upon the importance of route, traffic carried and Max^{m} permissible speed. M.G. routes are classified in three categories as Q.R. and S. routes.

(1) 'Q' Routes:

These routes consist of routes where the max^{m} permissible speed will be more than 75 Kmph. And the traffic density will be more than 2.5 GMT. Max^{m} speed do not exceeds 100 Kpmh. As Bangalore-Miraz route.

(2) 'R' Routes:

These routes will have a speed potential of 75 Kmph. and the traffic density will be more than 1.5 GMT. Routes have further been sub-divided into 3 category depending upon the volume of traffic as follows:

(a) R_1: Where the traffic density will be more than 5 GMT.
(b) R_2: In between 2.5 GMT to 5 GMT
(c) R_3: 1.5 GMT – 2.5 GMT

(3) 'S' Routes:

These routes will be the routes where speed potential will be less than75 Kmph and where the traffic density is less than 1.5 GMT. These will consists of other routes which are not covered in 'Q', 'R_1', 'R_2' and 'R_3' routes.

'S' Routes have been further subdivided into 3 routes as S_1, S_2 and S_3 etc.

RAILS

It is a special type rolled steel bar which is placed end to end two parallel line at a fixed distance on sleeper to provide continuous, leveled and smooth surface for train to move.

Or

Rails are similar to steel girder placed end to end at gauge distance to provide continuous, leveled and smooth surface for giving path to running wheel.

FUNCTIONS OF RAILS:

Following are the main functions:-

(i) Rails provide a continuous and leveled smooth surface for running wheels of trains.

(ii) It provides a path way which is smooth and has very less friction like $1/6^{th}$ of road.

(iii) The rails serve as a lateral guide for running of wheels.

(iv) The rail wear various types of mechanical stresses such as vertical load, braking forces, and thermal stresses due to temperature etc.

(v) Rails carry out the functions of transmitting load to a large surface area of formation through sleeper and ballast.

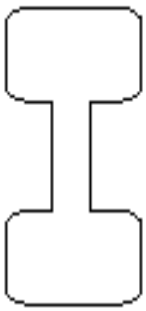
TYPES OF RAIL:

Various types of rails are:-

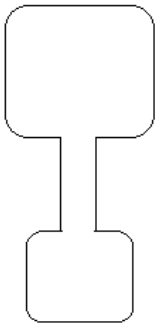
1. Double Headed rail (D.H .Rail)
2. Bull Headed Rail (B.H.Rail)
3. Flat Footed Rail (F.F.Rail)

(1) Double Headed Rail (D.H. Rails):

It is 'I' section or 'dumb-bell' section type rail having identical heads on both sides. Idea was that these rails were re-used after wear, by reversing it.



(2) Bull Headed Rail (B.H .Rails):

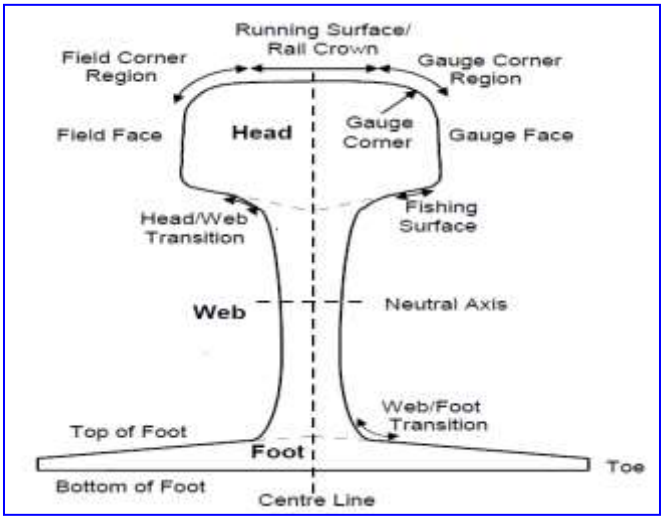


The shape of these rails is similar to D.H.R. and only difference is that its head has more metal to allow wear & tear, so that it may run for long life.

The idea was that these rails will have long life but due to unb head and problem in gauge maintenance, these rails were not succe rails.

(3) Flat Footed Rails (F.F.Rails):

These rails are having inverted 'T' cross-section and can be directly fixed to the sleeper with the help of spikes. These rail have been standardized for use in Indian Railways. These rails have more economical design giving greater strength & Lateral stability.



STANDARD LENGTH OF RAIL:

The Longer rails are not only economical and gives smoother and comfortable riding of trains. The length of rails is however, restricted due to the following factors.

- Lack of facilities for transport of longer rails particularly on curves.
- Difficulties in handling of long rails.
- Uneconomical in manufacturing very long rail.
- Difficulties in having a bigger expansion joint for long rails.
- Heavy internal thermal stresses in long rails.

However standard rail length of B.G. track is 13 meters.

Standard Gap at Fish Plate Joint

a. Standard gap for B.G. Fish Plate joint is **6 mm**.
b. Maximum gap can be accumulated at the rail joint in normal condition is **15mm**.

Standard Rail Section

The rails are designated with its weight per unit length. In India,initially we opted British/Revised British system in FPS system (Foot Pound Second),the rail section was designated in lbs per yard.

For Example: 90 R lbs rail section means weight of rail section is 90 lbs per one yard length by Revised British System.

Presently in Indian Railway Standard [I.R.S] MKS (meter /Kilogram sec] system is in co-operation in which we designate the rail system weight in kilogram / meter

For Example: 52 kg rail section means the weight of one meter rail is 52 Kgs

Nowadays we are manufacturing only the following two rails

(i) 60 Kg
(ii) 52 Kg

Note: Nowadays for laying new rails/ Gauge conversion etc only 60 Kg rail is considered as standard

Rolling mark on rails:

Every rail rolled has a brand on its web, which is repeated at certain intervals is called rolling mark:
Details are as follows

British Standard Rolling Mark

MM ➔IR – 90RBS-TISCO-II/ 1983 OHP

The abbreviations used indicates

a. MM : This indicates the material medium manganese steel
b. ➔ : Direction of Rolling
c. I R : Owner of the Rail [Indian Railways]
d. 90 : Weight and type of section; 90 lbs/yard rail
e. RBS: Revised British standards.
f. TISCO : Manufacturing Company Tata iron and Steel Company
g. II/ 1983 : Month and year of manufacture; February 1983

Indian Railway Standard Rolling Mark

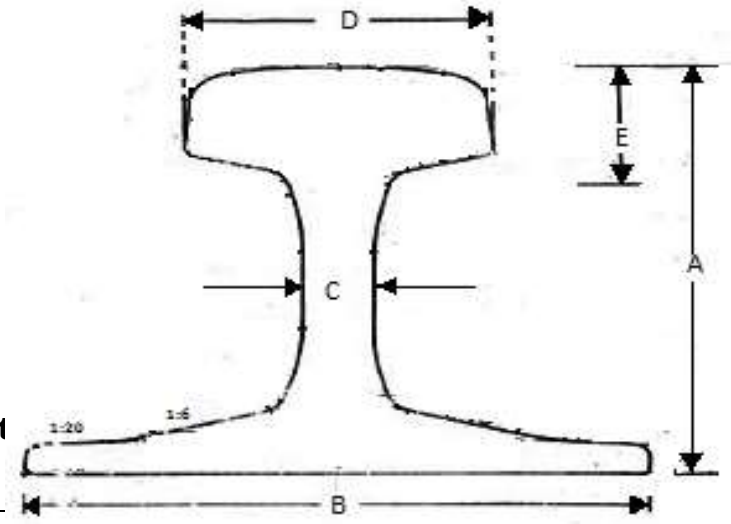
IRS-52kg-710-TISCO/SAIL-II 1997➔ OH

The explanation for various new abbreviations is as given below:

a. IRS : Indian Railway Standard
b. 52 Kg : Weight of rail section; 52 kg / meter
c. 710: Grade of the rail material
d. ➔ : Direction of Rolling
e. TISCO/SAIL : Manufacturing Company Tata iron and Steel Company/Steel Authority Of India Ltd
f. II/ 1997 : Month and year of manufacture; February 1997
g. OH: Manufacturing Process Open Hearth Process

Standard Dimension of the Flat Footed Rail:

Rail Section	Height (A) in mm	Flange Width (B) in mm	Web Thickness (C) in mm	Top Width (D) in mm	Top Height (E) in mm	Actual Weight in Kg
60 Kg	172	150	16.5	74.3	51	60.34
52 Kg	156	136	15.5	67	51	52



Relationship bet nd Service Life of Rails

Grade	Ultimate Tensile Stress(UTS)	Type of Rail	Stipulated Service Life
710	72	52 Kg	350 GMT
		60 Kg	550 GMT
880	90	60 Kg	800 GMT
		52 Kg	525 GMT
1080	110	60 Kg	Under Trial

Handling Of 90 UTS Rail

While Handling a 90 UTS rail special care should be taken following are the important points to be taken into account

- Protection of straightness
- Protection of rail surface
- Protection of Metallurgical Surface
- Protection from contact of other products
- Slinging Arrangement
- Personnel Safety

Slinging Arrangement:

Sl.No	Rail Length In (m)	Lifting Point	Distance Between Lifting Point in (m)	Over Hanging in (m)
1	13	2	6.5	3.25
2	26	4	6.5	3.25
3	39	6	6.5	3.25
4	130	20	6.5	3.25
5	260	40	6.5	3.25

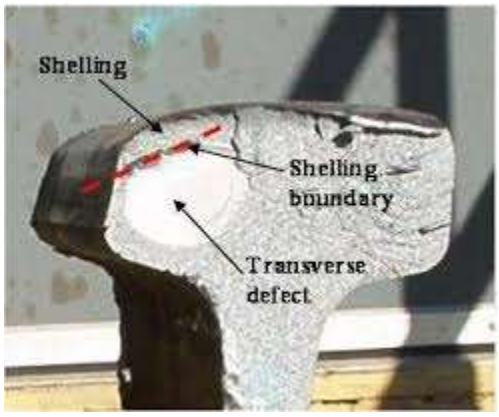
Note: Details of the Handling Of 90 UTS Rail is given in the **LWR manual**. It can be read from the manual.

Ultra Sonic Flaw Detector (USFD)Testing of Rail

Brief Idea:

There are two types of testing which are carried out in tracks

i. Rail testing (70° of probe is used)
ii. Joint testing (0° and 70° of probe is used) Rail flange testing by 0^{o} probe



Rail Testing (Frequency)

1. Initial Testing : in the rolling mill (or) in manufacturing plant
2. First Retesting : After passing of the 15% of stipulated GMT
3. Subsequent Testing

Service GMT/Annum	**Frequency of Rail Test in Months**
Less Than 8 GMT	12 Months
8 GMT to 12 GMT	9 Months
12 GMT to 16 GMT	6 Months
16 GMT to 24 GMT	4 Months
24 GMT to 40 GMT	3 Months
Above 40 GMT	2 Months

Weld Testing Frequency:

GMT	**90 UTS**	**72UTS**
UPTO 10 GMT	18 Months	24 Months
10 GMT to 20 GMT	12 Months	18 Months
20 GMT to 30 GMT	9 Months	12 Months
30 GMT to40 GMT	6 Months	9 Months
40 GMT to 50 GMT	4 Months	6 Months
Above GMT	3 Months	4 Months

NoteI: *This Ultra Sonic Testing frequency is normally decided by individual Zonal Railways as per their need . For quality control of USFD testing DEN/Track of the Division is responsible.*

NoteII: *Actual frequency of USFD testing is to be decided by different railways as per their requirement through CE Circular.*

Marking of USFD and Action taken:

S.No	Defects	Mark	Action Taken
1	IMR [Rail]	XXX (3 red X marks on both faces of rail)	1. Remove immediately within 30 days 2. Impose 30 Kmph caution Immediately 3. Fish Plate the particular location immediately with the help of clamp or Fish plate 4. Depute one watchman for round the clock till removal 5. Replace by 6m USFD tested rail
2	IMR [Weld]	XXX(3 red X mark on Both Sides of weld)	1. Impose 30 Kmph Caution Immediately 2. Provide Joggle fish plate within 24 Hours 3. After the Provision of joggle fishplate speed can be increased up to 70 Kmph 4. Rest of action will be taken as per IMR (Rail)
3	OBS [Rail]	X (one Red mark on both side of the rail)	1. Provide Joggle fish plate within 3 days 2. Key man should keep for watch everyday 3. Remove within 30 days
4	OBS[Weld]	X (one Red mark on both side of the Weld)	1. Provide Joggle fish plate with 4 bolts within 3 days 2. Key man should keep for watch everyday
5	Defective Flange [Weld]		1. If renewal(CTR) sanctioned then provide joggle fishplate and watch. 2. If renewal(CTR) is not sanctioned then defective weld will be joggled and 30 Kmph caution will be imposed till its removal within 15 days

IMR : Immediate removal , OBS: Observation

SLEEPERS

Sleepers are the components of track on which rails are fixed with the help of fittings and fastenings in correct gauge and alignment.

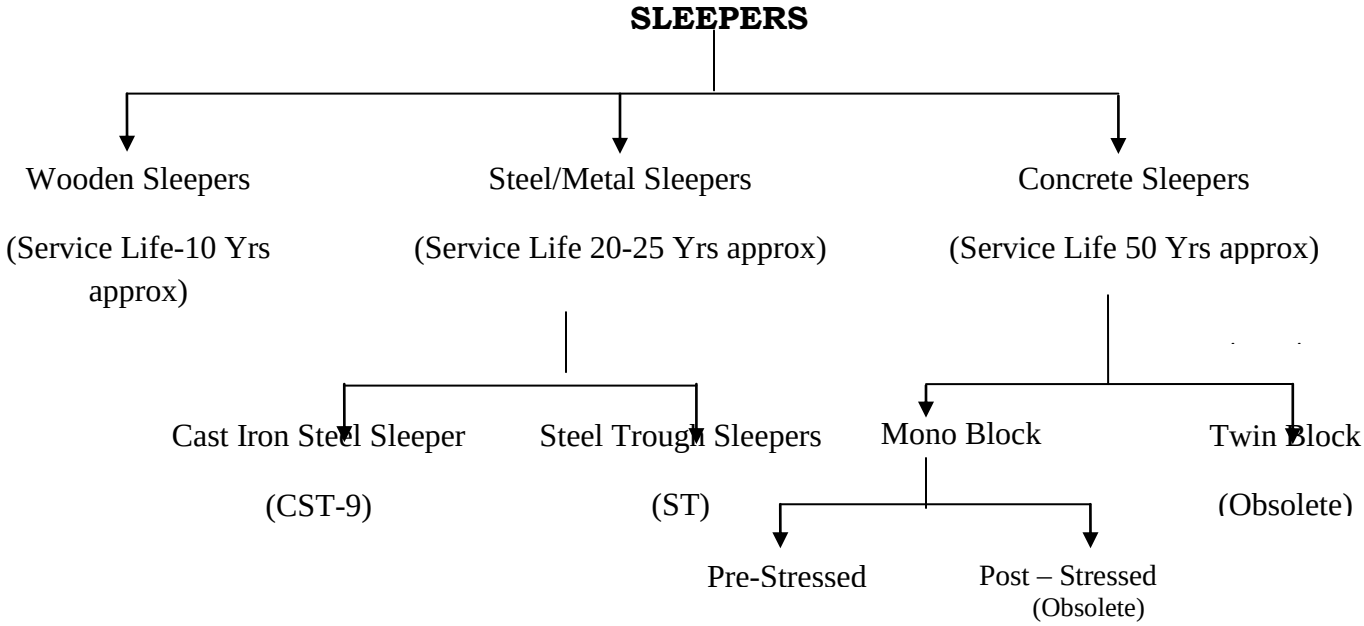
The sleepers in the initial stages were planted in the longitudinal direction of rails. These were known as Longitudinal Sleepers. These types of sleepers were not economical so they changed to transverse sleepers.

Functions of sleepers

The main functions of the sleepers are as follows

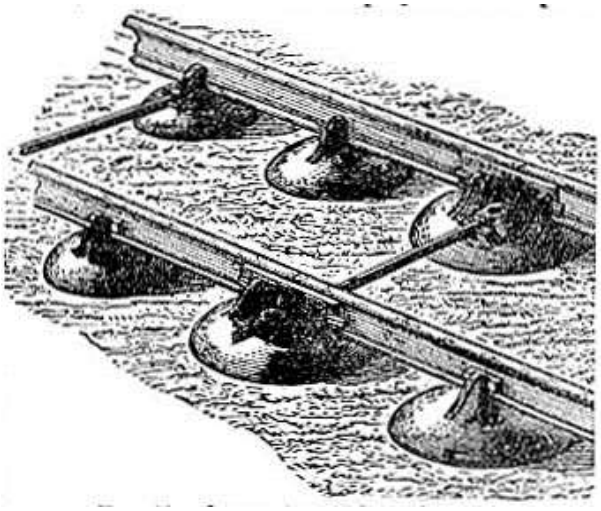
1. It should hold the rail in correct gauge and alignment.
2. It should give a firm and even supports to rails.
3. It should transfer the load evenly and efficiently from rails to the wider area of ballast section.
4. Act as an elastic medium between rail and ballast to absorb shocks and vibrations of moving loads.
5. It provides longitudinal and lateral stability to permanent way (Track).

Types of Sleepers:



Note: Now-a-days in Indian Railways monoblock Pre-Stressed Concrete Sleepers(PSC)/ monoblock Pre-Reinforced Concrete Sleepers(PRC) are considered as an standard.

Wooden sleepers



Cast Iron sleepers

Steel Trough Sleepers

PRC Sleepers-Monoblock

Dual Block Concrete sleepers

Requirement of Good Sleepers

The ideal sleeper should normally fulfill the following requirements:

i) The initial cost as well as maintenance cost should be minimum (low).
ii) The weight of sleeper should be moderate, so that it is possible to handle it easily.
iii) The design of sleeper and fastenings should be such that it is possible to fix and remove the rails easily.
iv) It should have sufficient bearing area
v) It should be such that it is possible to maintain and adjust gauge properly.
vi) It should be able to bear the load coming from rail comfortably and should not break/damage under load.
vii) It should be 'Universal Type' and may be used in track circuiting area
viii) It should be able to absorb the shock and vibration coming from moving train.
ix) It should be able to provide elastic medium between rail and ballast.
x) It should be designed in a way that quantity of loose parts and fasteners should be less.
xi) It should have good service life.
xii) The sleeper should have anti-sabotage and Anti-theft quality.

CONCRETE SLEEPER

Necessity of concrete sleepers:

The use of concrete sleepers in Indian Railways becomes necessary due to following reasons.

i) Scarcity of good quality of timber.
ii) High cost of maintenance in wooden and steel sleepers.
iii) Introduction of high speed and heavier axle loads.

Advantages of Concrete Sleepers:

1. Concrete sleepers being heavy, gives greater strength and stability to track and are suitable specially for LWR/CWR due to great resistant to buckling.
2. Concrete sleepers with elastic fastening provide a track which can maintain better gauge, cross level and alignment and retains packing well.
3. Since Concrete sleepers have flat bottom therefore they are best suited for modern methods of tamping and maintenance (i.e. machine maintenance).
4. These can be used in track circuited areas (or) track circuited section as they are poor conductor of electricity.
5. They are neither inflammable nor subjected to be damaged by atmospheric effect (corrosion) and insects.
6. These have longer service life approx 50 years. Compared to other type of sleepers.
7. It has anti-sabotage and anti-theft quality.
8. It is fit and forget type.
9. No chance of gauge widening.
10. Availability of PRC sleeper is easy. They can be made at the site also.
11. They can be produced on large quantities locally by installing a plant.

Disadvantages Of Concrete Sleepers:

1. Due to heavy load, handling of PRC sleepers are not easy only Machine handling is recommended which is costly
2. In case of derailment, these sleepers may get heavy damage.
3. These sleepers have nil scrap value.
4. Not useful for better packing. So only machine packing is allowed.

Specification of Mono Block (PRC Sleepers):

S.No	**Parameter**	**52 Kg Sleepers**	**60 Kg Sleepers**
1	Length	2750 mm	2750 mm
2	Height at ends	210 mm	235 mm
3	Weight	270 Kg	286.5 Kg
4	Top Width	154 mm	150mm
5	Bottom Width	250 mm	270 mm
6	HTS dia (Reinforcement)	3 x 3 mm	3 x 3 mm
7	Number of Bars	18	18
8	Slope at top	1:20	1:20

Sleeper Density & Sleeper spacing

Sleeper Density

Sleeper Density means how many sleepers are provided in one rail length(i.e. 13 meters for B.G)

For BG sleeper density is denoted as (M+X) where

M = Length of rail in m

X = Variable

For example: In BG track (M+7) sleeper density means 13+7=20 sleepers per rail length. Nowadays for New laying, Doubling, Gauge renewal (M+8) is considered as standard

The sleeper density depends upon the following factors:

1. Axle load and speed of trains
2. Type and strength of sleepers
3. Type of rail and its section.
4. Type of the ballast and ballast section
5. Nature of formation.

Sleeper Spacing

Sleeper spacing means centre to centre distance between adjacent sleepers which are provided in the rail. It depends upon the sleeper density.

Sleeper spacing is kept uniform in whole rail length but at joints it's kept close as joints are the weakest portion of track and needs more support.

Sleeper spacing at the joint is kept close in such manner so that space for packing should be available sufficiently and end of rail should be as a 'bridge joint' not supported at sleepers.

Standard Spacing for BG

Type of Sleeper	**Sleeper Spacing**			
	A	**B**	**C**	**D**
Wooden	150	610	In Between B & D is to be calculated to be equally divided in remaining length	
Metal	190	580		

Sleeper Spacing and density in LWR joint

Sleeper density in LWR track is although denoted as same as in rail length i.e (M+4),(M+7) or (M+8) but for conventional and all practical purpose it is given as number of sleeper per kilometer.

The sleeper spacing in LWR track is calculated as 1km divided by number of sleepers in one kilometer of rail.

Sleeper density	No. of sleeper per kilometer	Exact c/c spacing required as per calculation in cm	C/c spacing to be provided in the filed (cm)	
			L.W.R.	S.W.R.
M + 8	1660	60.24	60	-
M + 7	1540	64.93	65	66
M + 4	1310	76.33	76	78

Note: Normally M+4 density is only used in SWR tracks.

1. The above rail spacing (M+X) will be applied only on curve up to 4° in BG and 6° in MG.
2. Curve more than 4° in BG and 6° in MG, midslaggery if joints are provided.
3. Outer rail of curve will be reference line for all practical purpose related to spacing.
4. In LWR track since there is no joints hence spacing will be as usual. Also there are restrictions to lay the LWR on curve for more than 4° in BG.

FITTING AND FASTENINGS

Types of Fitting And Fastenings

Rail to Rail (Fish plate)

1. Ordinary Fishplate
2. Compound/Combination Fishplate
3. Joggle Fishplate
4. Long Fishplate

Rail to Sleeper

Rigid Fastenings

Rail Free Fastening

1. Dog Spike
2. Round Spike
3. Screw Spike

Anti Creep Type

1. Keys (2 way, Single Way)
2. Beach Plates

Elastic Fastenings

1. Pandrol clip or Elastic Rail Clip (ERC)
2. IRN 202 Clip
3. IRN 204 Clip
4. Double Shank Elastic Fastening(DC-18)
5. Single Shank Elastic Fastening(DC-18)
6. Lock Spike
7. Rubber Pad (Fittings)

RAIL TO RAIL FITTINGS:

These fittings are used for tying one rail to another longitudinally in same horizontal and vertical plane. One of the main fittings of such types of rail is fishplate. Fishplate is called, so as its section looks like a fish.

TYPE OF FISHPLATE:

Fishplates are of following two types:

i) Ordinary fishplate
ii) Combination fishplate.
iii) Joggle Fishplate
iv)Long FishPlate

(i) Ordinary Fishplate:

These plates are having I-section. These are used to connect similar line section together, such as 90R rail to 90R rail and 60 Kg rail to 60 Kg rail.

(ii) Combination Fishplate:

These are used for connecting the rail length of two different rail sections. Such as 90R rail to 52 Kg rail, 52 Kg rail to 60 Kg rail. The combination fishplates are designed

so as to suit the two rail sections. No expansion gap is kept at such joints so as to give more strength. A common top table and gauge face of the two rail section is available with the help of the Junction fish plates or combination fish plates in-spite of varying depth & thickness of the section.

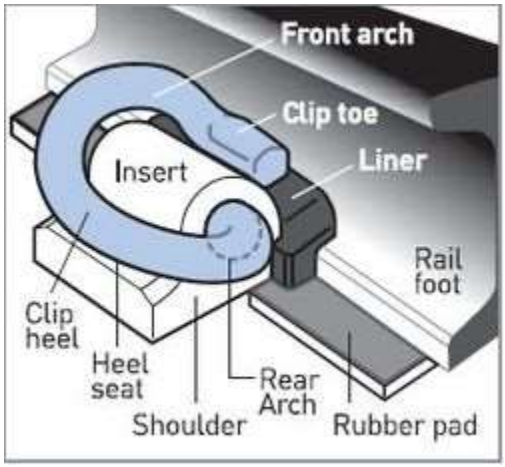
(iii)Joggle Fishplate:

These fishplates are very similar to ordinary fishplate for particular rail section with only difference its mid portion is projected outside to accommodate weld material at welded joints. Hence it is used only at welded joints.

(iv) Long Fishplate:

These fishplates are very similar to ordinary fishplate for particular rail section but longer in length exactly 1 metre.These fishplates are used at the location where the higher joint strength is required.(with 6 bolts).**For Example**:near to LWR territory or at glued joint etc.

Elastic fastenings



The Primary function of the fastenings is to connect the rail with the sleepers. The Elastic fastenings serve this and in addition to that it has an additional property of elasticity after fixation (Toe Load and deflection etc). So that it is very useful to absorb the vibration, shocks and jerks etc coming from moving train by this additional property. These fittings are very useful for modern high speed track because these fastenings do not loosen and get off due to vibration and load effect. Hence it may be fit & forget type.

Requirement of Elastic Fastenings:

An idle elastic fastening should be able to meet the following requirement

- It should hold gauge well
- It should have adequate 'toe load' which should not reduce under service.
- It should provide sufficient elasticity to absorb the shocks and vibrations coming from moving train
- It should keep the track parameter well maintained
- It should offer adequate resistance to lateral and longitudinal track for maintaining the stability of track.
- It should be anti creep type.
- It should be reusable type
- It should be fit and forget type
- It should have minimum loose parts so that its fixation and maintenance should be easy
- It should be free from sabotage and anti theft type.
- It should be cheap and have long life
- It should be universal type so it can be used with any type of sleeper.

Type of Elastic Fasteners

1. Pandrol clip or Elastic Rail Clip (ERC)
2. IRN 202 Clip
3. IRN 204 Clip
4. Double Shank Elastic Fastening(DC-18)
5. Single Shank Elastic Fastening(DC-18)
6. Lock Spike
7. Rubber Pad (Fittings)

Pandrol Clip/ Elastic Rail Clip (ERC)

Note: Material of Pandrol Clip: **Silico Manganese Spring Steel (SMSS)**

Types of Elastic Rail Clips(in Use):

1. Elastic Rail Clip- Mark-I
2. Elastic Rail Clip- Mark-II
3. Elastic Rail Clip- Mark-III
4. Elastic Rail Clip- Mark-IV
5. Elastic Rail Clip- Mark-V

All the ERC'S are of two types they are

1. Flat Type-used at joint of track circuited areas.
2. Round type-normal use.

Type	**Toe Load (Kg)**	**Toe Deflection (mm)**	**Bar Diameter(BD) (mm)**	**Weight (gm)**
MARK-I	645-800	11.4	20.64	1000
MARK-II	700-900	11.2	18	800
MARK-III	**850-1100**	**13.5**	**20.64**	**910**
MARK-IV	1100-1300	13.5	20.64	855
MARK-V	1300-1500	15.5	22	1000

Note : Now a days ERC Mark-III is widely used in Indian Railway Compared to other Types.

Rubber Pad

It is an integral part of the elastic fastenings. It is provided between Rail and Sleepers to Perform following duties

i. To absorb the shocks
ii. It dampens and absorb the vibration
iii. It resists the longitudinal movement of rail
iv. It prevents the abrasion of rail sleeper
v. It provides electrical insulation between rail and sleepers in the electrified area's

Note: Normally in Indian Railway groove Rubber Pad of 6mm is used with PRC Sleepers

Liners:

Liners are used with pandrol clips on PRC sleepers to prevent 'dent, mark on rails produced due to toe load. In Indian Railways normally insulating composite liners are used. There are three types as follows

i. Composite liner with Mild steel and nylon Component
ii. Composite liner with Mild steel and nylon Component/ P.V.C Liners
iii. Composite liner with Mild steel and Glass Filled Nylon(GFN)

Note: Nowadays in Indian Railways Liners with GFN are considered as standard liners.

BALLAST

Ballast is the layer of broken stone, gravel, moorum or any other hard material that are placed and packed below and around sleepers for distributing load to larger area of formation. This is receiving through sleepers and providing drainage as well as longitudinal and lateral stability of track.
Broken Stone – grit.

Functions of Ballast:

1. To transfer and distribute the load from sleeper to a large area of formation.
2. To provide elasticity and resilience to track for getting proper riding comfort.
3. To provide necessary resistance to track for longitudinal and lateral stability.
4. To provide effective drainage to track.
5. To provide effective means of maintenance.

Type of Ballast:

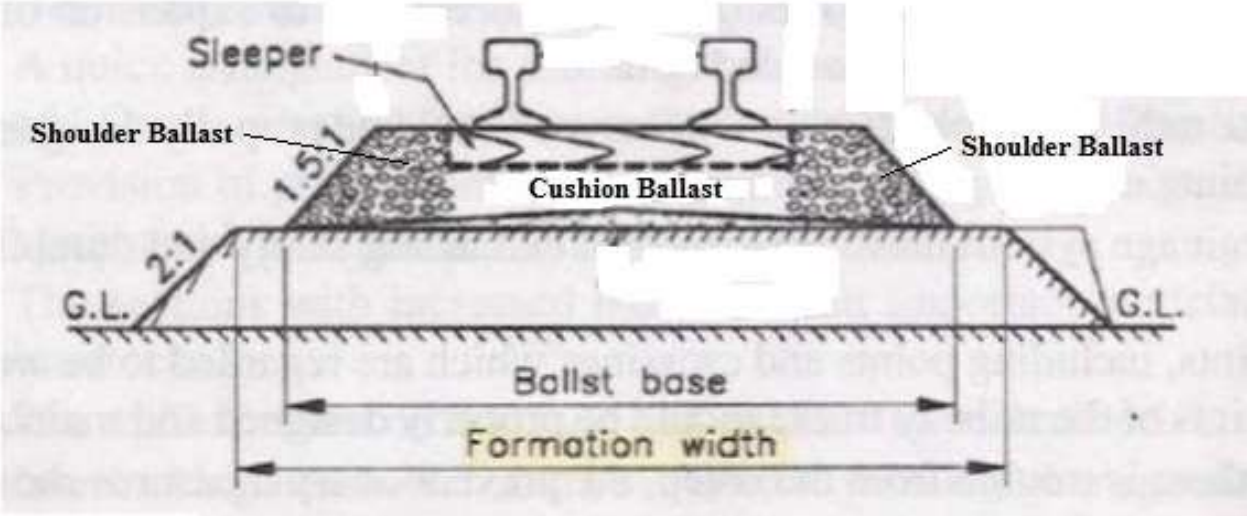
Sand, Moorum, Coal Ash as sinter, Broken Stone Ballast, Brick Ballast, Kankakee etc.
Note: Nowadays in Indian Railways stone ballast is considered as standard.

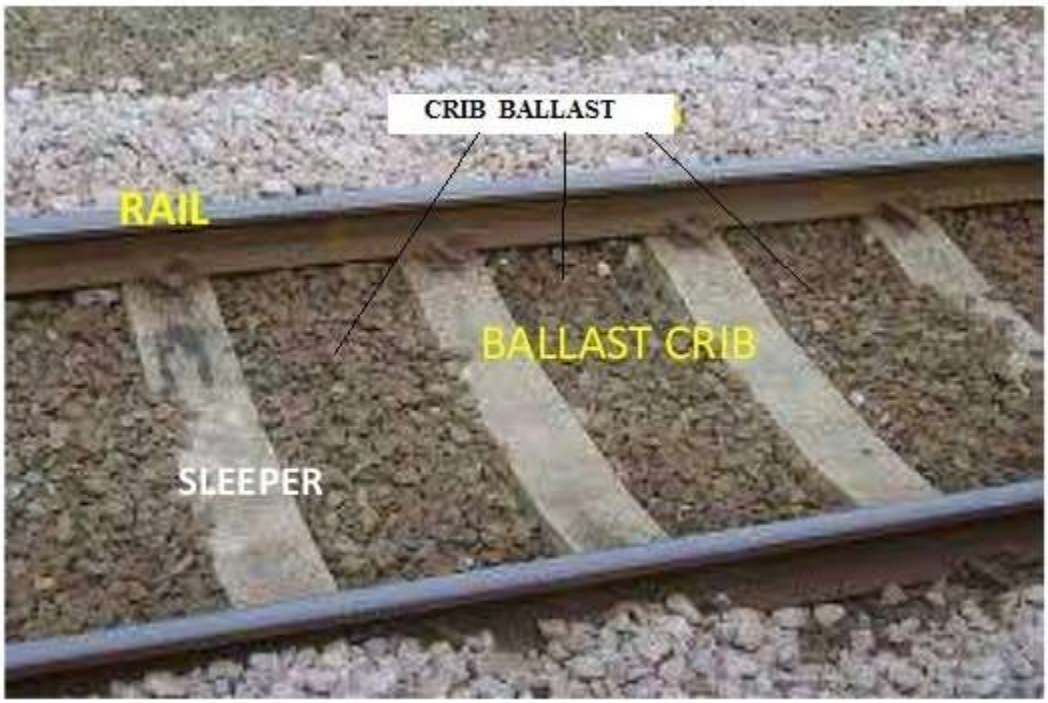
Requirement of a good Ballast:

1. It should be tough and wear resistance.
2. It should be hard and should not be crushed under moving load.
3. It should be cubical in shape and should have sharp edges
4. It should be non-porous and non-absorbent of water.
5. It should be durable
6. It should provide good drainage to water.
7. It should be cheap and economical in price and easily available.

Classification of ballast according to position in track and its use:

1. Ballast under the sleeper are known as Cushion Ballast
2. Ballast outside the track/sleeper is known as Shoulder Ballast
3. Ballast in between the sleepers is known as Crib Ballast





Function of Cushion Ballast:

1. Absorb the shocks and vibration received from moving trains through sleepers
2. To distribute the load received through rails and sleepers of moving train and larger area of formation.
3. To provide a leveled surface layer to the track this will be able to maintain the track parameter like cross level and evenness.
4. To provide elasticity and resilience to track for passenger comfort.
5. To provide drainage to track.

Function of Shoulder Ballast:

1. To provide lateral stability to track as well as resilience to buckling etc
2. To provide effective drainage to track
3. To help maintain the alignment of the track.

Function of Crib Ballast:

1. To provide longitudinal stability to track.
2. To help the sleeper for proper spacing and in a square position.

Recommended Ballast Cushion:

A & B Route: 300mm
C&D Route: 250mm
E Route: 150 to 200 mm
Note: Nowadays for new laying recommended ballast cushion on 60 kg PRC track is 350mm.

Ballast Specifications:

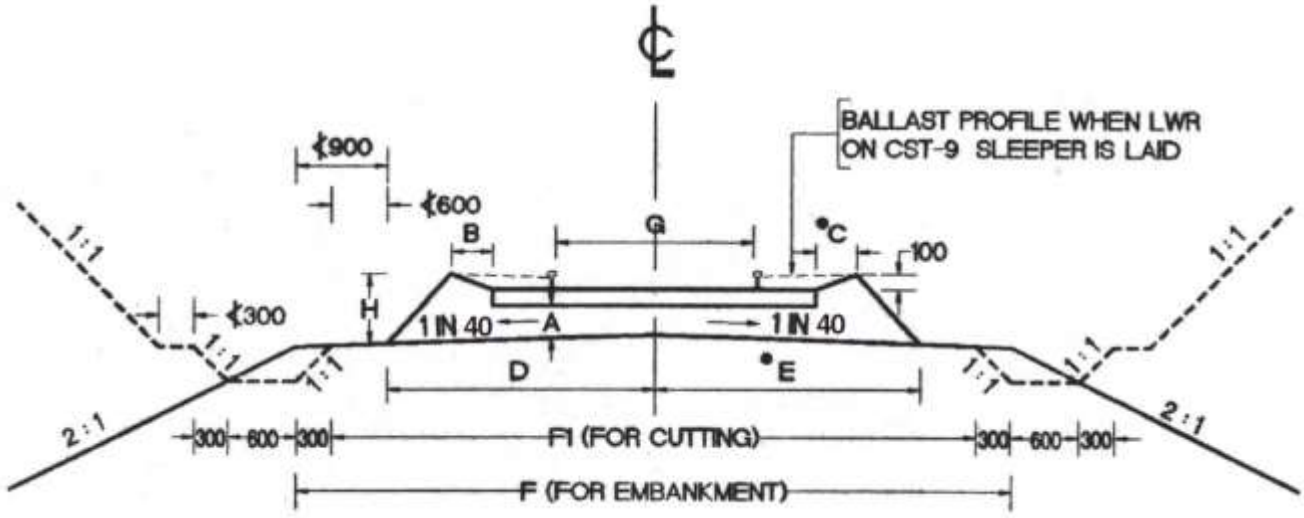
Ballast should be cubical in shape, angular, hard and free from organic impurities durable, non porous and non water absorbent. It should resist attrition. It should be manufactured by machine crushing preferably otherwise hand crushed ballast should be used after the approval of CTE . It should be cheap and economical. Ballast should not be flaky .

Size of Ballast and Its Gradation:

In Indian Railways standard size of ballast is **65mm** cubical.

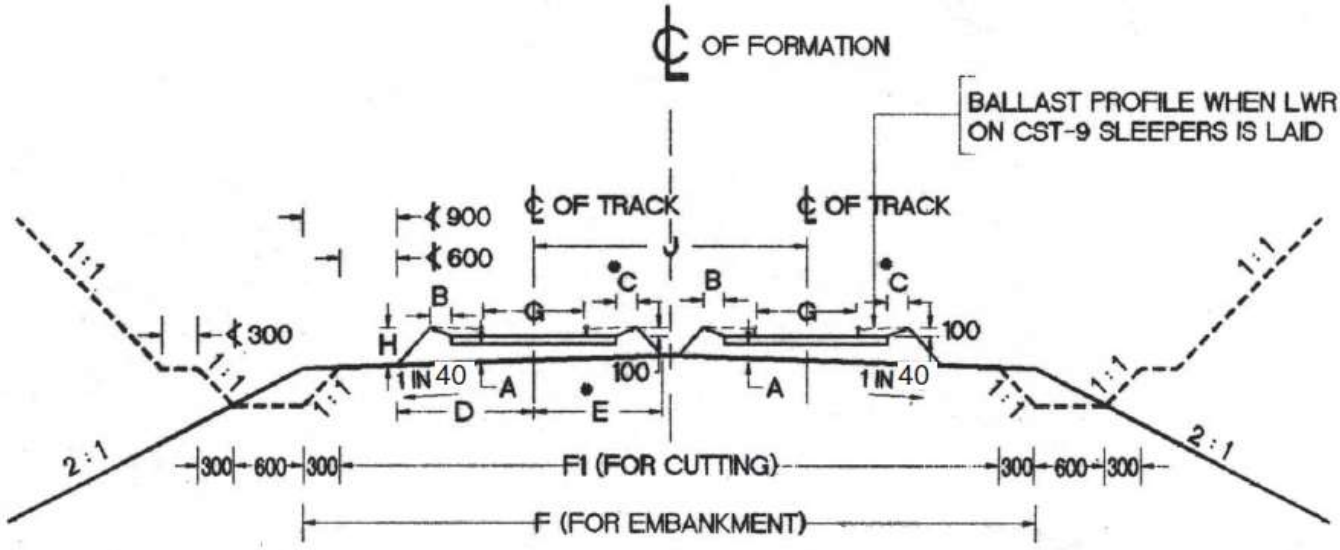
Ballast Profile:

FOR SINGLE LINE BG TRACK



G GAUGE	TYPE OF SLEEPER	A	B	*C	D	*E	F	F1	H
	PRC	250	350	500	2525	2675	6850	6250	640
		300	350	500	2525	2675	6850	6250	690
		200 OVER 150 SUB-BALLAST	350	500	2525	2675	6850	6250	740

FOR DOUBLE LINE BG TRACK



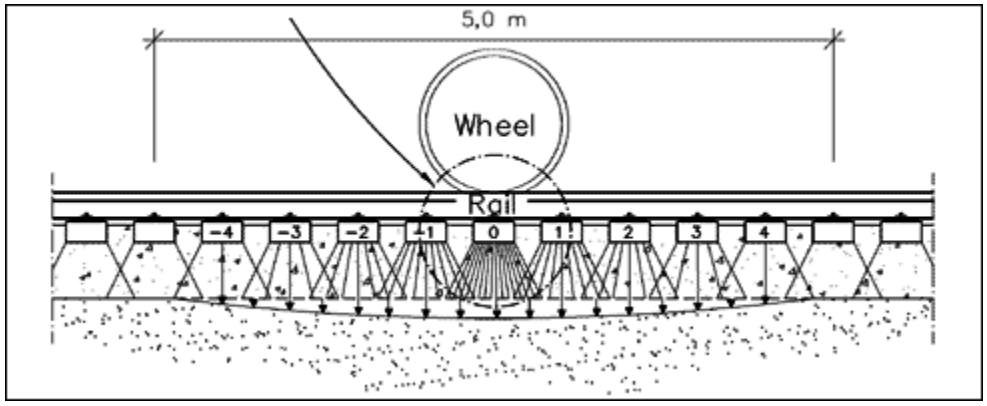
G GAUGE	TYPE OF SLEEPER	A	B	*C	D	*E	F	F1	H	J
	PRC	250	350	500	2525	2460	12155	11555	700	5300
		300	350	500	2525	2460	12155	11555	750	5300
		200 OVER 150 SUB-BALLAST	350	500	2525	2460	12155	11555	800	5300

Note:

1. The minimum clean stone ballast cushion below the bottom of sleeper ie A=250mm
2. For routes where speeds are to be more than 130 Kmph, A=300mm or 200mm along with 150 mm of Sub-Ballast.
3. *On outer side of curves only-500mm on sharp curve,600mm on reverse curve.
4. Suitable slope shall be given for side slope of ballast profile.
5. Dimensions for formation width(F and F1) are given for straight portion only this should be suitably increased taking into account extra ballast shoulder on outside of curves and for super-elevation.
6. All dimensions are in mm.

Pressure Distribution on Ballast:

This is given by Mr.B.M.Talbhot.



Note:

1. The pressure distribution curve under the sleeper is in shape of Bulb.
2. Pressure on sleeper is maximum in the centre of its width decreases centre towards end.
3. The vertical pressure under the sleeper is uniform at a depth which is equal to sleeper spacing approximately.
4. Distribution of load is roughly takes place at 45°.

Formation

It is prepared flat surface on which track is laid.

It is the important constituent of track which supports the entire track structure and gives a strong base to absorb the moving load of the train.

Types of Formation:

It is normally of two types :

1. Embankment
2. Cutting.

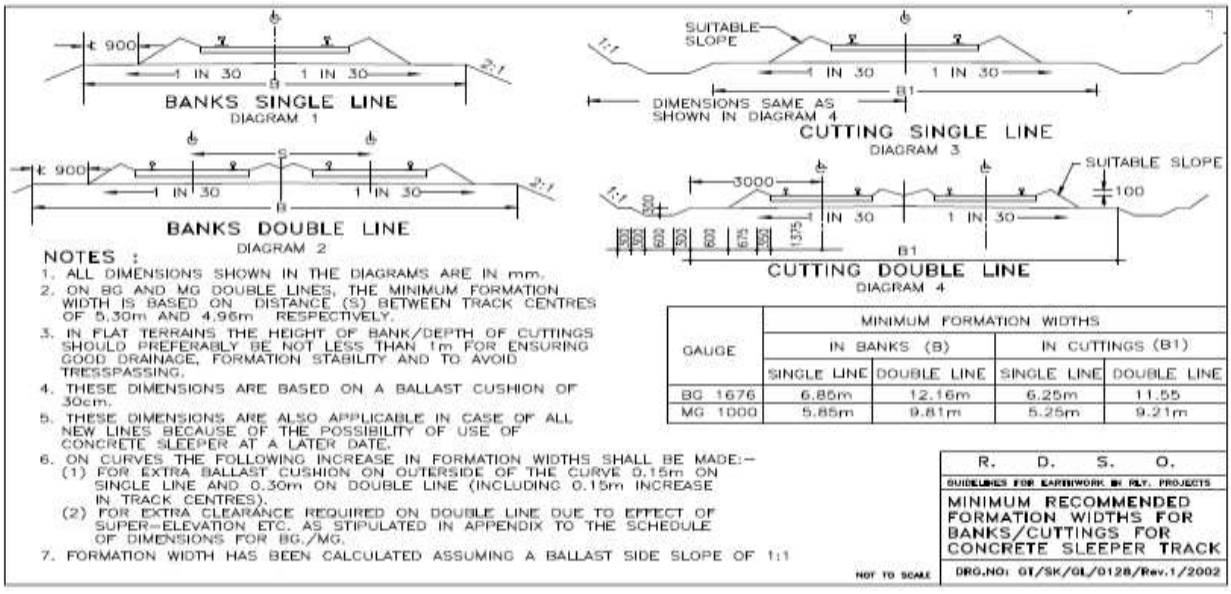
Embankment:

It is prepared by making some additional earthwork over existing ground up to required height from ground level.

Cutting:

Formation in cutting is prepared by additional excavation of existing excess ground surface up to the required depth. Normally it is made in 'hilly' areas.

Note: Zero fill formation: Formation where the track is laid on ground level is called zero fill formation.



Function of Formation:

(i) To provide a smooth & uniform bed for laying of track.
(ii) To bear the static and dynamic loads transmitted to it through ballast section.
(iii) To facilitate drainage
(iv) To provide stability to the track.

Recommended Width Of Formation:

Width of the formation depends upon the number of the track and their gauge to be laid.

However recommended standard width is as below

S.no	Type of formation	Track	Broad Gauge (BG) (meter	BG Recommended With (SOD-2002) (meters)	Meter Gauge (meters)
1	Embankment	Single line	6.10	6.851	4.38
		Double Line	10.82	12.150	8.34
2	Cutting	Single line	5.49	6.250	4.27
		Double Line	10.21	11.550	8.23

Height of formation:

Height of formation depends upon the

1. Ground contour
2. Gradients
3. Maximum Flood Level (MFL).

Slope of Formation:

The side slope of both embankment and cutting depend upon.

1. Shearing strength of soil
2. Angle of repose

In actual practice the areas of soil like sand (or) clay may required the slope

		Horizontal : Vertical
For Embankment	➔	2:1
For Cutting	➔	1:1 (or) 1 ½ : 1

Sub-Grade:

The formation without 'Sub-Ballast' is known as Sub-Grade.

Sub-Grade Material:

Material used for making formation is known as sub-Grade material. Normally it is obtained from the borrow pit from the adjoining land.

Example: Gravel, Coarse Sand, Medium sand, fine sand and silt.

Requirement of Sub Grade Materials

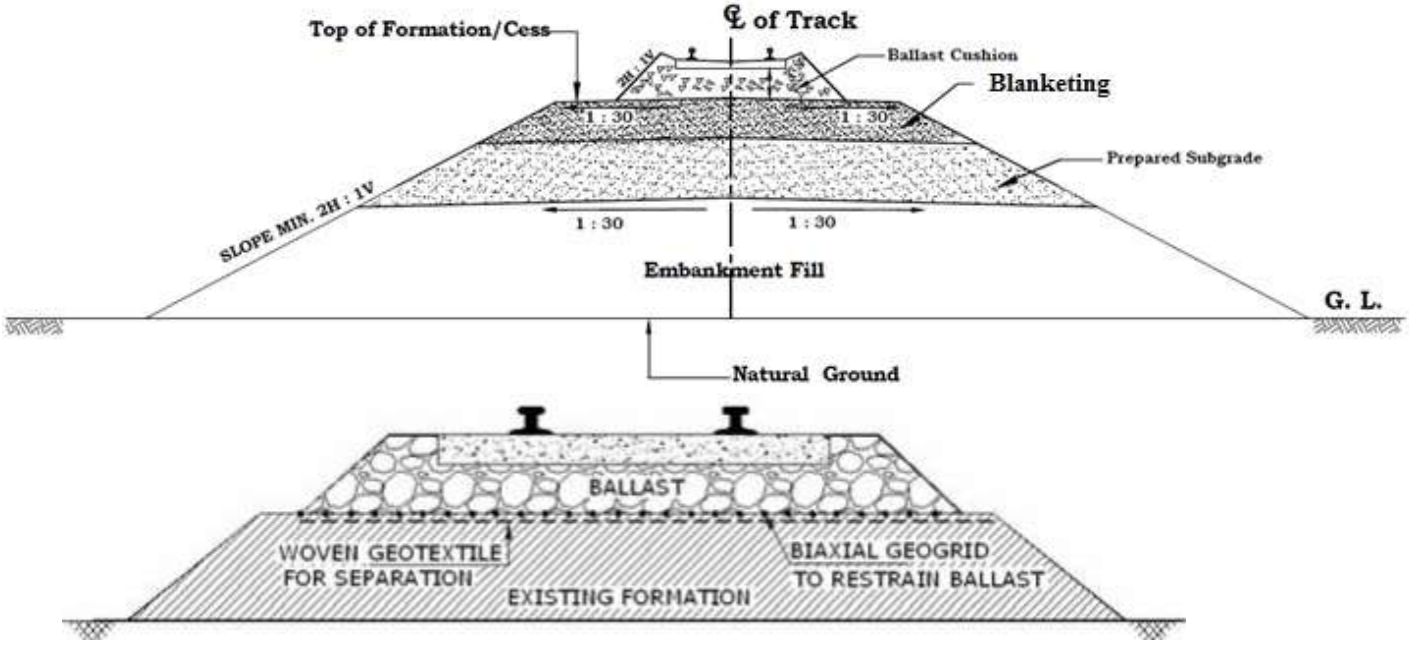
1. It should be able to bear the load transferred to it by ballast section.
2. It should prevent the ballast to puncturing in it.
3. It should drain the water efficiently entering top.
4. It should not change its volume due to variations in moisture.

Characteristics of Sub Grade materials:

1. It should be dense, free from moisture and high internal friction and cohesion; otherwise, it will tend to flow (or) spread out in present of excessive moisture.
2. It should posse's low capillary to keep the formation free from excessive moisture.

Blanket (or) Blanketing over formation:

Blanket can be defined as an intervening layer of superior material which is provided on the top surface formation bank. Just underneath of ballast cushion. It is different than sub ballast.



Function of Blanketing:

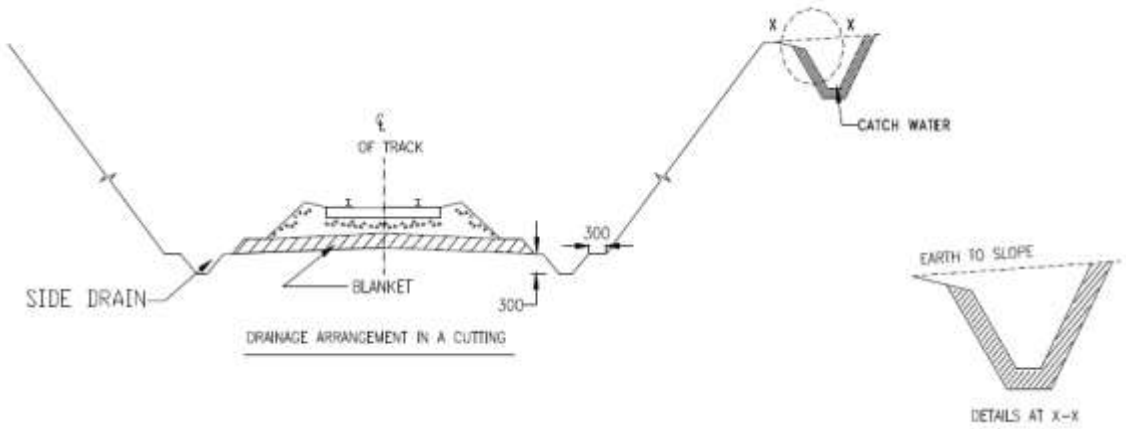
1. To minimize the penetration of ballast into the formation
2. To reduce the ingress water, rain water in soil

TRACK DRAINAGE

Track drainage is defined as the interception, collection and disposal of water from upon (or) under the track.

Presences of excess moisture of water, reduces the bearing capacity of soil as well as resistance to shear resulting the failure of Formation, Hence proper drainage of track is very very essential.

Drains



Catch Water Drain:

In cutting formation water coming from up levels to track is interrupted, collected & drained through a drain made on slopes of cutting. This type of drain is known as catch water drain. Maximum section area of catch water drain should not exceed 0.75 m^2.

Side Drain

In cutting water coming from top surface of the formation is drained through a drain at neath of side slope is known as 'Side Drain'.

Cess:

The width of formation beyond toe of ballast to end of formation is known as cess. This additional width beyond ballast provides stability to formation.

Recommended Track Distance (Formation Profile).

Recommended minimum track centre distance (C/C distance) shall be as under

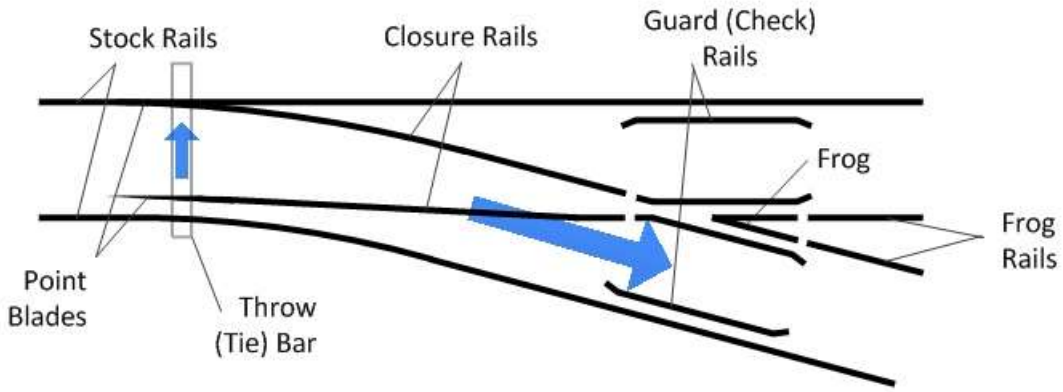
1. For existing track – 4.725 meters
2. For New laid track – 5.300 meters

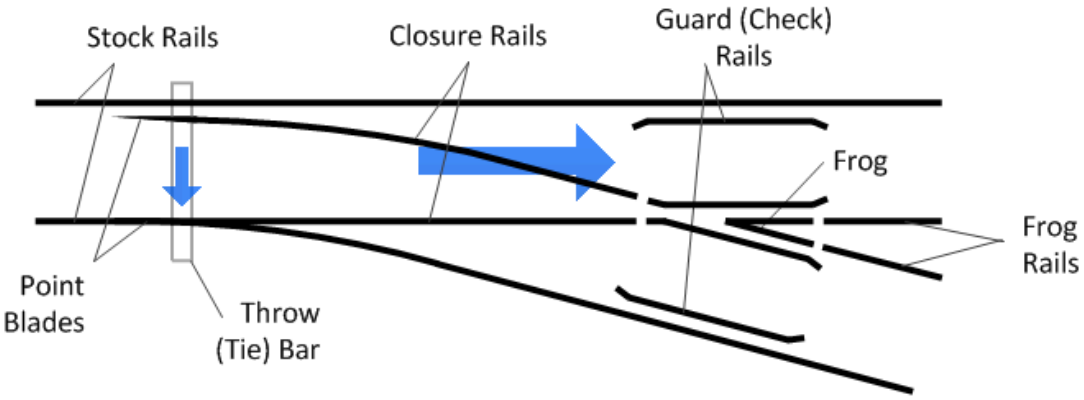
POINTS & CROSSING

Necessity of Point & Crossing

Point & Crossing i.e. turnout are necessary due to following reasons:

1. On single line track to give path to trains coming from both directions.
2. In double line, to give path to faster train against slow train coming from same direction
3. To connect the places which are not lying on main line
4. To place/direct the passenger train to platform line (or) goods train to yard line for stay





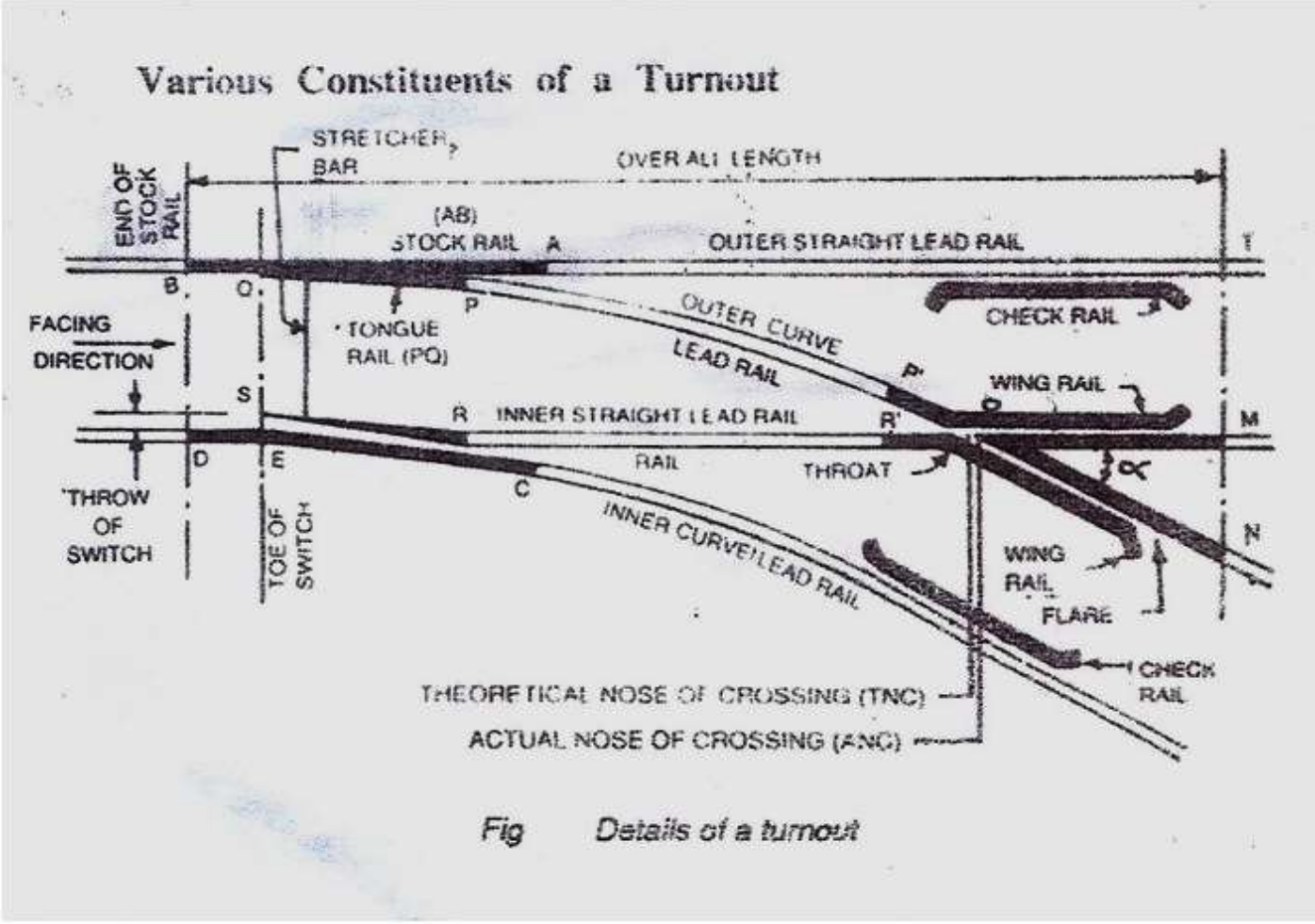


Fig Details of a turnout

SOME IMPORTANT DEFINITIONS OF POINTS AND CORSSING:

Tongue Rail:

It is the tapered movable rail made of high carbon and manganese steel to withstand wear whose thicker end is connected with running rail/ lead rail. Some time it is also known as Switch Rail .

Stock Rail:

It is the running rail in which the tongue rail is housed.

Switch:

A pair of tongue e rail with necessary connections and fittings forms a switch.

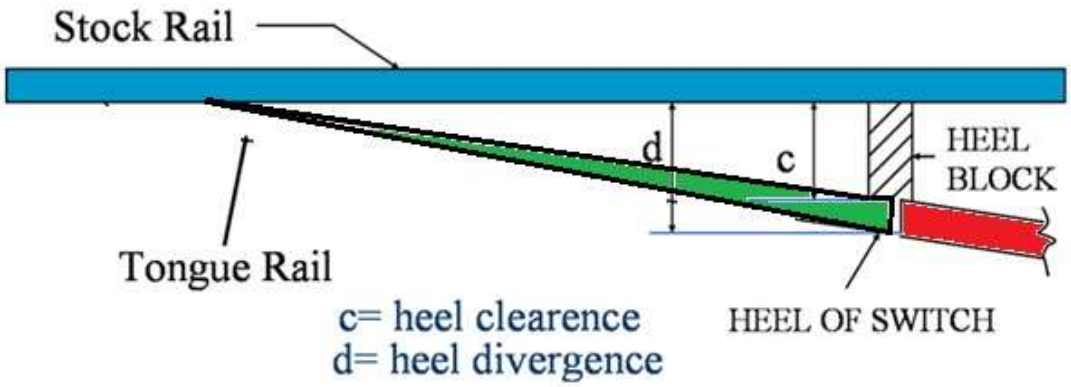
Point:

A pair of tongue rails and a pair of stock rails with necessary connections form a Point.

Heel of Switch:

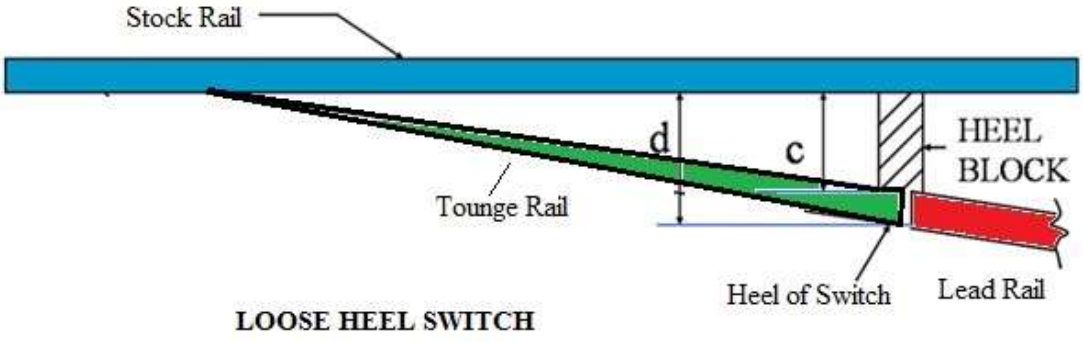
Heel of Switch is an imaginary point midway between the end of the lead rail and tongue rail in case of "loose heel switch."

In case of fixed heel switches it is the point at the centre of the heel block itself



Loose Heel Type:

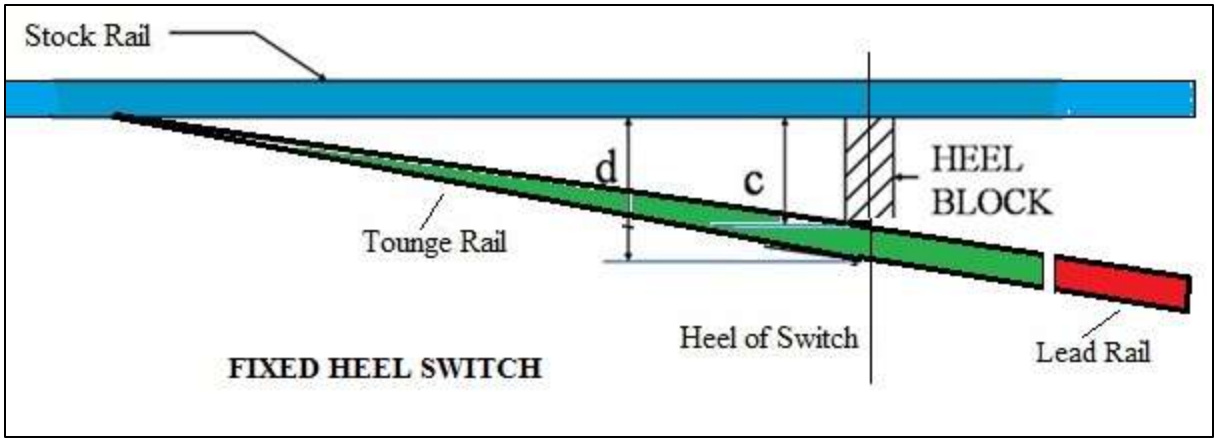
In this type, the switch rail or tongue rail finishes at the heel of the switch. In order to enable the free end of the tongue rail to be moved, two front bolts of the heel block are kept loose.



LOOSE HEEL SWITCH

Fixed Heel Type:

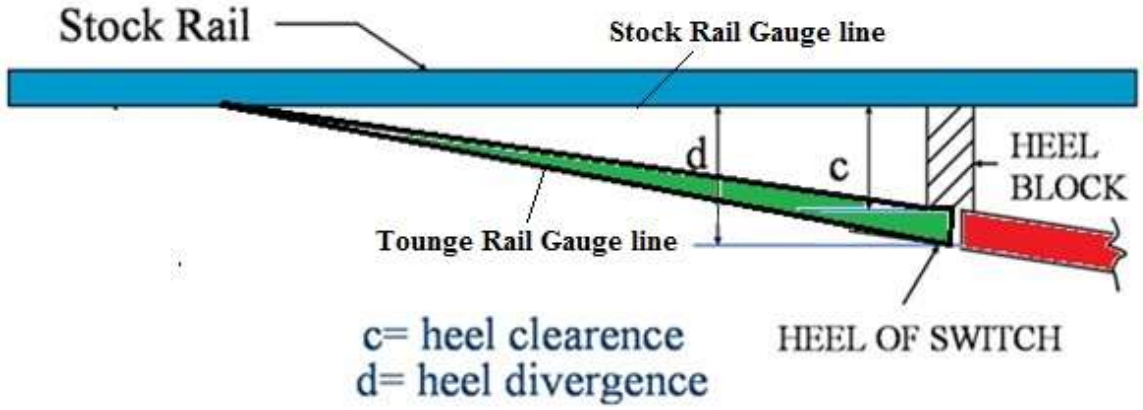
In this type of switch, tongue rail does not end at heel of the switch, but it extends further. The movement of the tongue rail is made on account of the flexibility of tongue rail by increasing its length.



Heel Divergence:

The minimum distance between gauge line of stock rail and gauge line of tongue rail at heel of switch is called Heel Divergence.

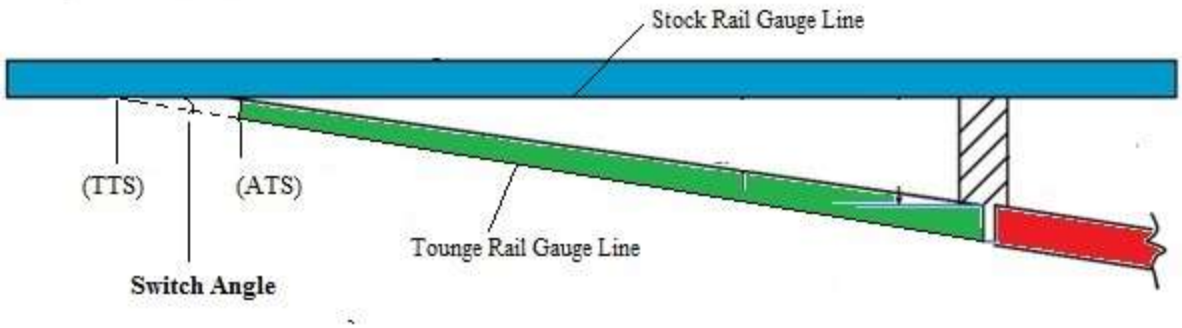
In other words it is the clearance between stock rail and running rail at HOS plus head width of tongue rail



Switch Angle:

It is the angle between the gauge lines of stock rail and tongue rail at theoretical toe of switch (TTS) in close position. This angle depends upon heel divergence and length of tongue.

In case of curved switches it is called as "**Entry Angle**".

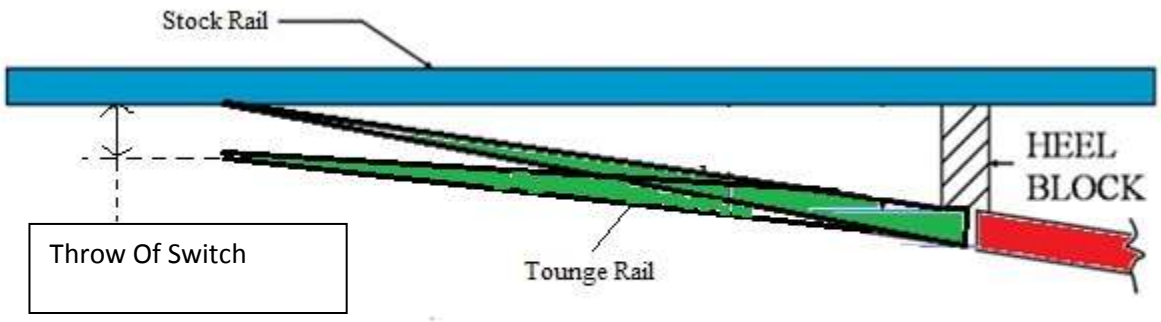


Note: In case of curved switches it is the angle between gauge lines of stock rail and tangent drawn at actual toe of gauge line of tongue rail. Hence it is called "Entry Angle".

The various switch angles in BG Track are as given below :

1 in 8 ½	Straight Switch	1°-34'-27"
1 in 12	Straight Switch	1°-8'-0"
1 in 8 ½	Curved Switch	0°-47'-27"
1 in 12	Curved Switch	0°-27'-35"

Throw of switch:



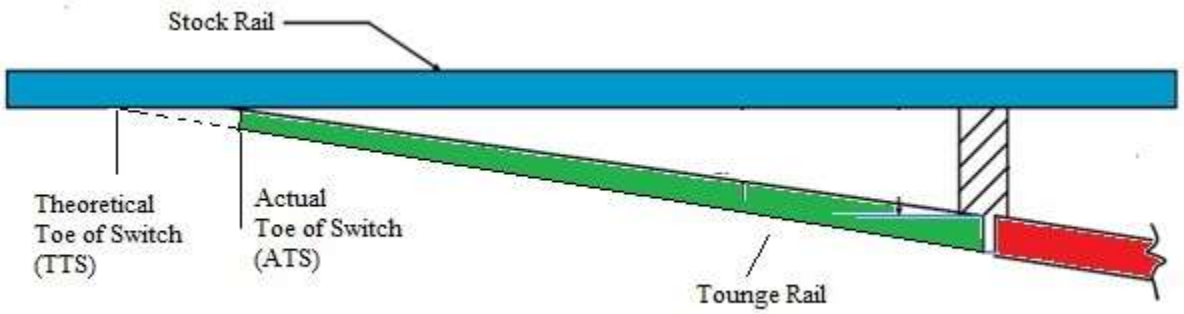
It is the distance moved by a tongue rail against stock rail at Actual Toe of Switch(ATS) at the time of making path to either side.

As per Schedule for Dimension (SOD) the maximum and minimum value of switch is as under following.

Track	Maximum Value in mm	Minimum value in mm
Broad Gauge	115	95
Metre Gauge	100	89

Toe of Switch or Actual Toe of Switch(ATS):

Thin tapered end of tongue rail is called Toe of Switch or Actual Toe of Switch(ATS)

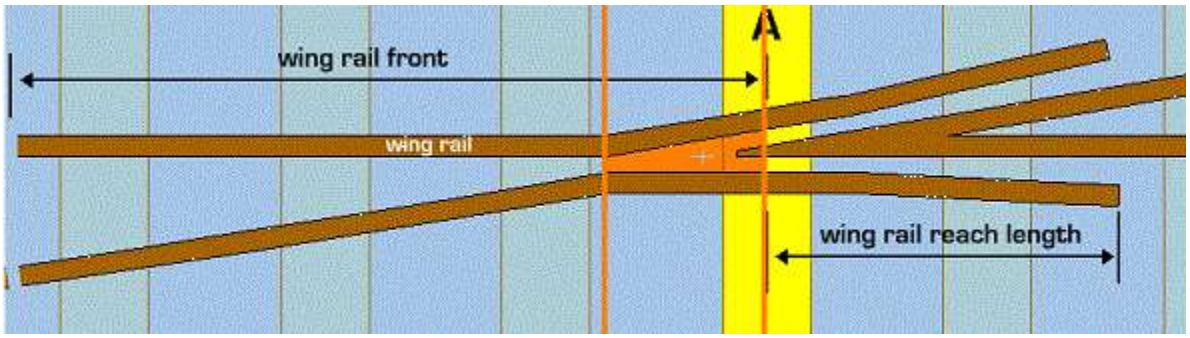


Theoretical Toe of Switch:

Theoretical toe of Switch is the point of intersection of gauge lines of tongue rail and stock rail in the closed position. It is imaginary point in field.

Crossing:

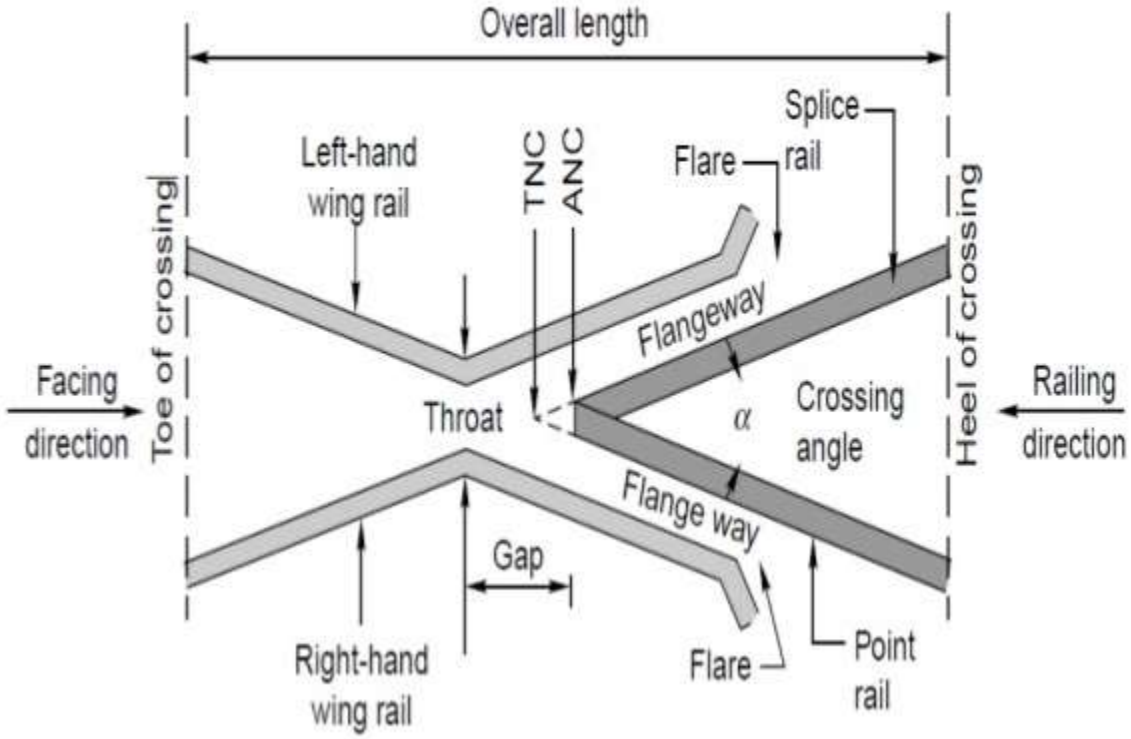
Crossing is a device introduced at the junction where two rails cross each other to permit the passing of the wheel flange of rolling stock, to pass from one track to another track. It is also known as “frog”.



Theoretical Nose of Crossing: (TNC)

Theoretical nose of crossing is a theoretical point of intersection of two gauge lines of crossing.

TNC is used as a reference for all Calculations.



Actual Nose of Crossing: **(ANC)**

Theoretical Nose of Crossing is the point which is not practically possible to provide in track. Some thickness is provided (Equal to web thickness of rail section) at nose to gives strength to the nose.

Hence actual nose of crossing is the point which spreads between the gauge lines of crossing at 'pointed end' which have sufficient thickness in view of giving strength and manufacturer consideration.

Throat of Crossing:

Throat of crossing is the portion at which the converging wing rail of crossing has minimum distance (closest position)

Note: Normally Throat clearance is kept 51mm.

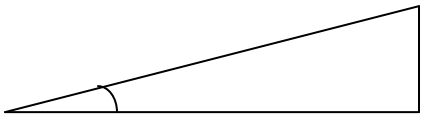
Number Of Crossing OR Crossing Number:

Number of crossing is the co-tangent value of the crossing angle.

Normally it is denoted as 1 in N, where N is crossing number .

For Example : 1 in 8 ½ , 1 in 12 etc

Both are standard crossing for IRS and are in use.



Crossing Angle :

Angle subtented between gauge lines of crossing nose piece is known as crossing Angle. It is measured at Theoretical Nose of crossing

The typical value of crossing angle is as below

1 in 8 ½ = 6°-42'-35"

1 in 12 = 4°-45'-49"

Numerical Problems(ANC to TNC Distances):

Question 1. Calculate the distance from ANC to TNC for 1 in 12 Crossing of 60 kg rail

Answer; For 60 kg rail section, web thickness = 16.5 mm

Now Cot Θ = $\frac{12}{1}$

The distance from ANC to TNC is = 16.5 x 12 = 198mm

Question 2. Calculate the distance from ANC to TNC for 1 in 12 Crossing of 52 kg rail

Answer; For 60 kg rail section, web thickness = 15.5 mm

Now Cot Θ = $\frac{12}{1}$

The distance from ANC to TNC is = 15.5 x 12 = 131.75mm ≈132 mm

Check Rail :

At the throat of crossing wheel flange jumps from one rail to another to cross the rail in gap.(flange way gap). In order to ensure that this wheel negotiate the gap properly and does not strike the nose, the other wheel is guided with the help of a parallel fixed rail at specified distance. This rail is called check rail.

As per SOD Minimum = 44mm

Maximum = 48 mm

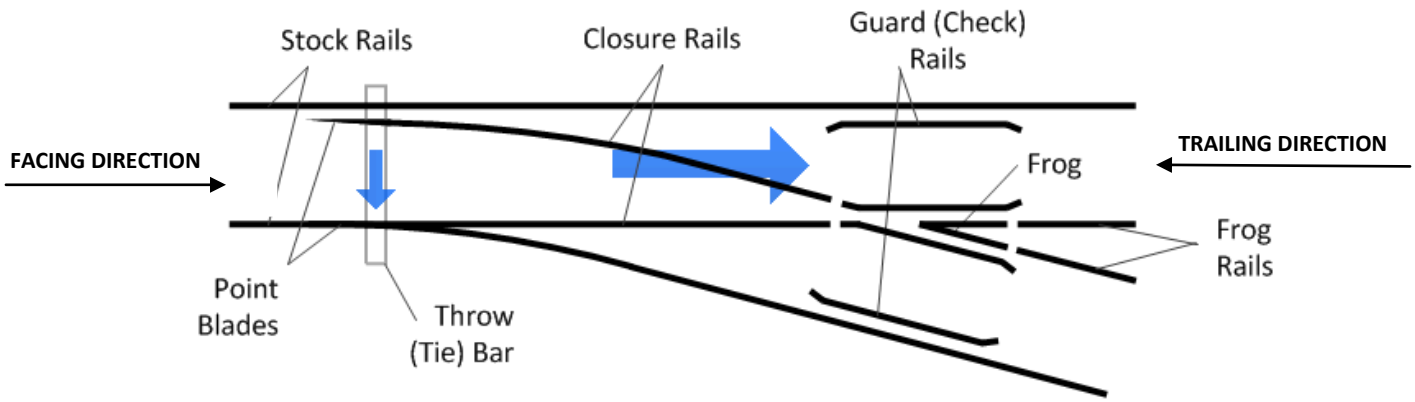
Turn Out:

Turnout is a device which is used to direct the vehicle from one track to another.

OR

It is an arrangement of points and crossing with lead rails by means of which rolling stock (Vehicles) may be diverted from one track to another track.

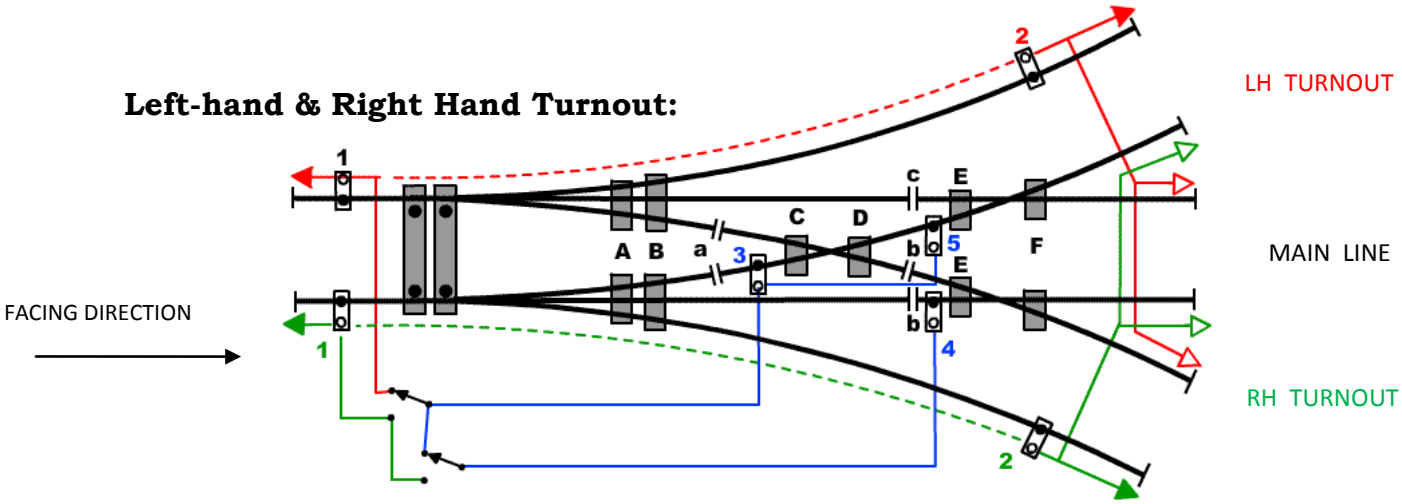
Facing Direction and Trailing Direction:



Train passing on turnout if first passes/crosses the point and then crossing. The direction of train / vehicle to be known as **Facing Direction**.

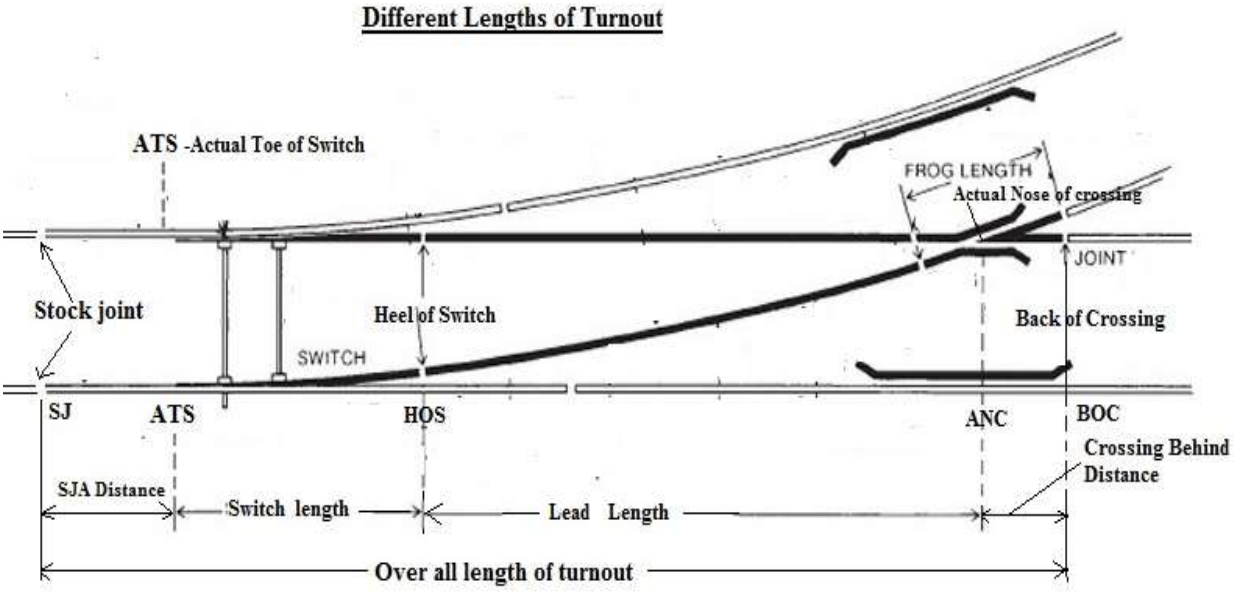
Train passing on turnout if first passes/crosses crossing portion and then switch portion. The direction of train will be identified as **Trailing Direction**.

Left-hand & Right Hand Turnout:



A turn out is designated as right hand or left hand depending upon whether the traffic is directed to right or to left respectively .

The vehicle approaching to turn out from facing direction if diverts right hand then it is denoted as Right Hand T/out if diverts left hand side – it will denoted as left hand turn out.



Stock Joints Ahead Distance (SJA Distance)

It is the straight distance from stock joint to actual toe of switch is known as Stock Joint Ahead Distance

Switch Length:

It is a straight distance from Actual Toe of switch(ATS) to Heel of Switch is known as switch length

Lead:

Straight distance from Heel of Switch to theoretical nose of Crossing is known as Lead.

Crossing Behind Distance:

It is the straight distance from TNC to Back of Crossing is known as Crossing behind Distance.

Overall Length of Turnout:

It is the straight distance from "stock joints" to "back of crossing" is known as overall length of turnout.

Over all length of turn out= SJA Distance + Switch Length + Lead Length + Crossing Behind Distance

Fouling Mark:

Fouling mark is a point between two adjacent tracks of turnout (behind crossing), where minimum distance as per SOD lies between two track centers so that vehicle on both track can safely passes.

Accessories of Point and Crossing:

Stretcher Bars
Gauge Tie Plates
Switch Stops
Slide Chairs
Heel Block
Distance Blocks
Crossing Distance Block
Check Rail, etc

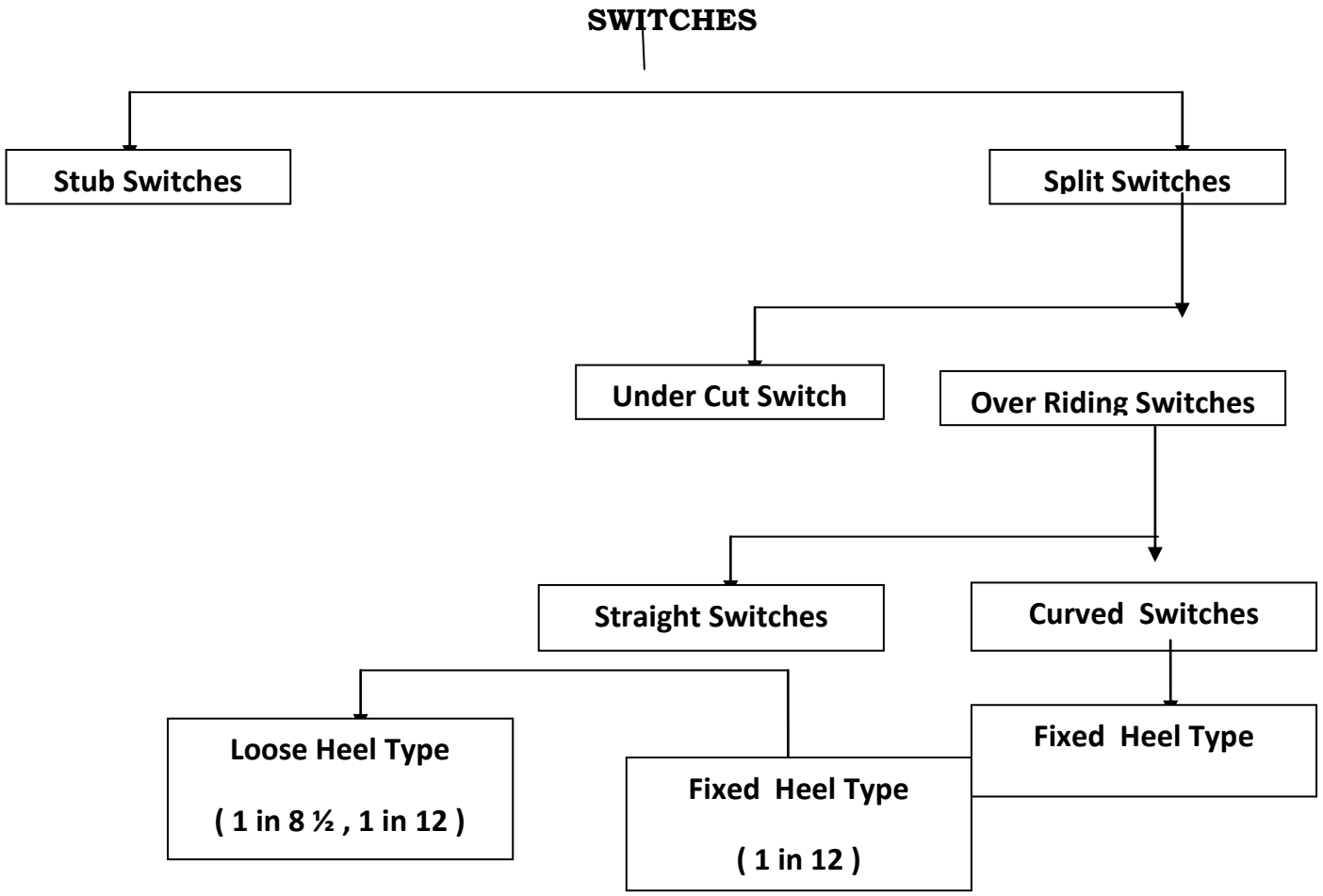
Important Notes :

1) Gauges are kept slack by 6mm at Actual Toe of Switch.

2) Exact gauges are maintained at nose of crossing to avoid hitting of the nose by moving flange.

SWITCHES

Types :-



STUB SWITCH:

In this type of switch, no separate tongue rail or stock rail is provided and some portion of the track is moved from one side to another side for giving path in either track. These switches are obsolete now.

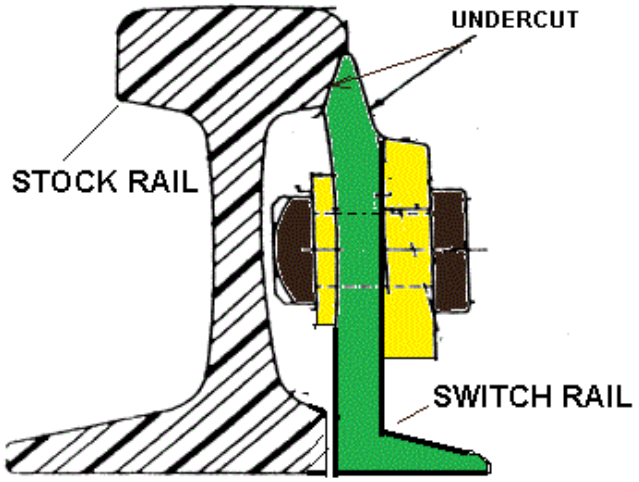
SPLIT SWITCHES:

This type of switches is in use in Indian Railways. It has a pair of stock rail and a pair of tongue rail. In split switches, only tongue rail is moved to give path to the train on either sides .

There are two types of split switches:

1. Under Cut Switch
2. Overriding Switch

UNDER CUT SWITCH:



These are old and obsolete type switches for Indian Railway. Initially in this type of switches foot of stock rail is planned/cut to accommodate the tongue rail.

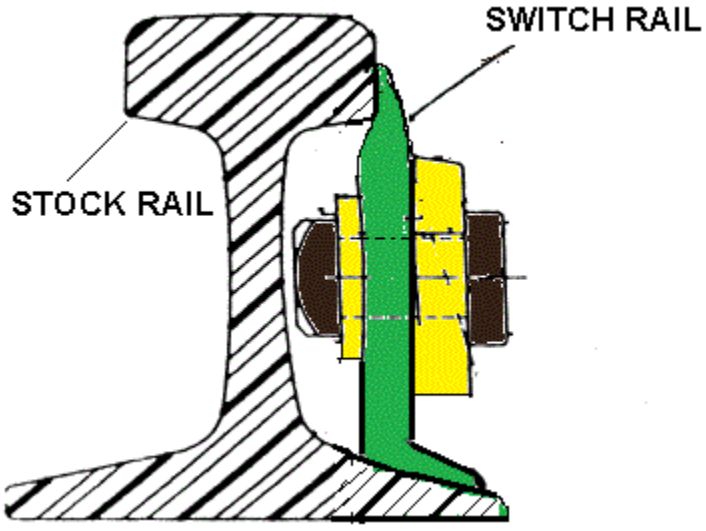
Under cut switches had following major two defects

1. First deficiency /defect was with tongue rail. It was planned in such a manner so that thickness of the toe was reduced to almost nil. Due to this, it worn out in very short period of service (Due to rubbing of wheel and load coming through wheel) and service life of tongue rail was very very short.

2. Second deficiency was in stock rail itself. Due to planning, Cutting of the flange, it becomes week and in under load it start to break

Due to above reasons these switches are now obsolete. To overcome above problems of undercut switches overriding type switches are designed. Which are the standard switches of the Indian Railway.

OVER RIDING SWITCH:



In this type of switch the stock rail has the full section and the tongue rail is planned to 6mm thick edge which over rides on the foot of the stock rail. In this design the thickness of tongue rail at toe is 6mm,but top surface of the tongue rail is planned in such a way so that it never comes under load unless and until half of the head width not receive by moving wheel.

In this design, tongue rail looks weak but in fact it is very strong. After over riding on the stock rail foot, it becomes stronger. Also up keeping by 6mm at HOS to joint behind the wheel in case of fixed heel, reduces the chances of splitting of point.(In case of trailing direction moment and due to moment of false flange wheel.)

Advantages of Overriding Switches:

Over riding switches are more economical and superior design due to following reason

1. Since there are no cut in stock rail and have full rail section, it is much stronger.
2. Since manufacturing work is involved only in tongue rail, hence it is more economical and easy to manufacture.
3. Although the tongue rail has the thin edge of 6mm but it is supported by the stock rail for the entire weak portion of its length. This gives it more combined strength and chance of damage in tongue rail is eliminated.

Type of Overriding Switches

1. Straight Switches
    a. Short with loose heel
    b. Long with fixed heel
2. Curved Switch (Normally Longer Switches)

Straight Switches:

Switches having straight tongue rail is known as straight switches.

The straight tongue rail had advantage that these are simple in manufacturing and same tongue rail can be used for left hand Turn out and right hand Turnout.

But also has a disadvantage that there is an abrupt change observed in alignment at ATS resulting negotiating trains observe jerk while entry in turn out.

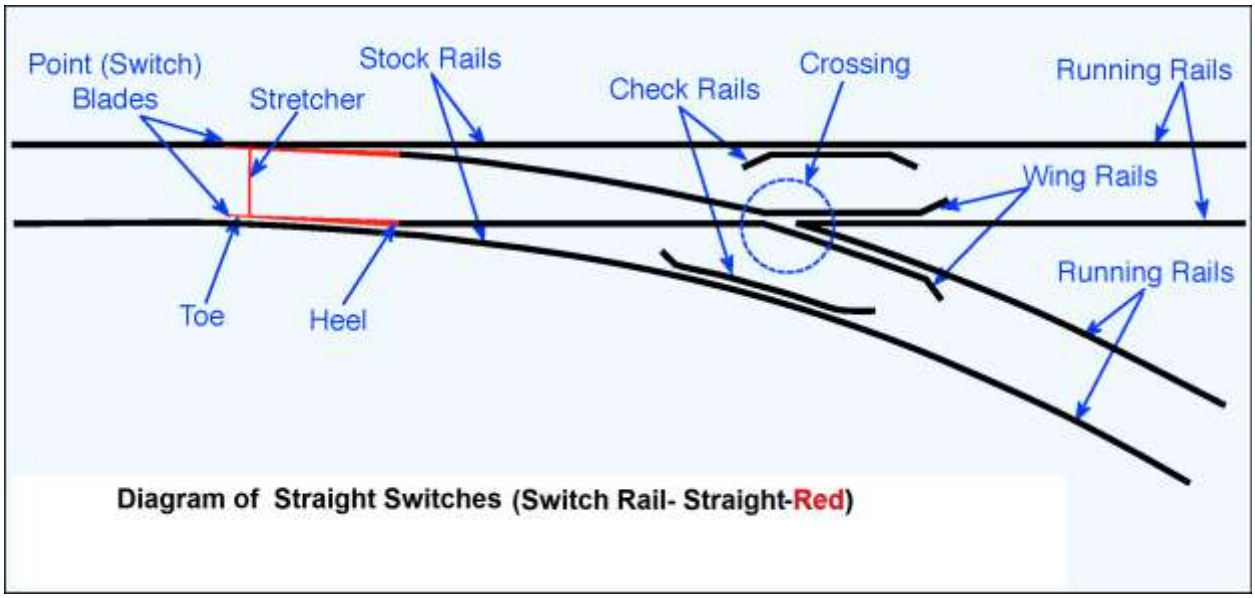
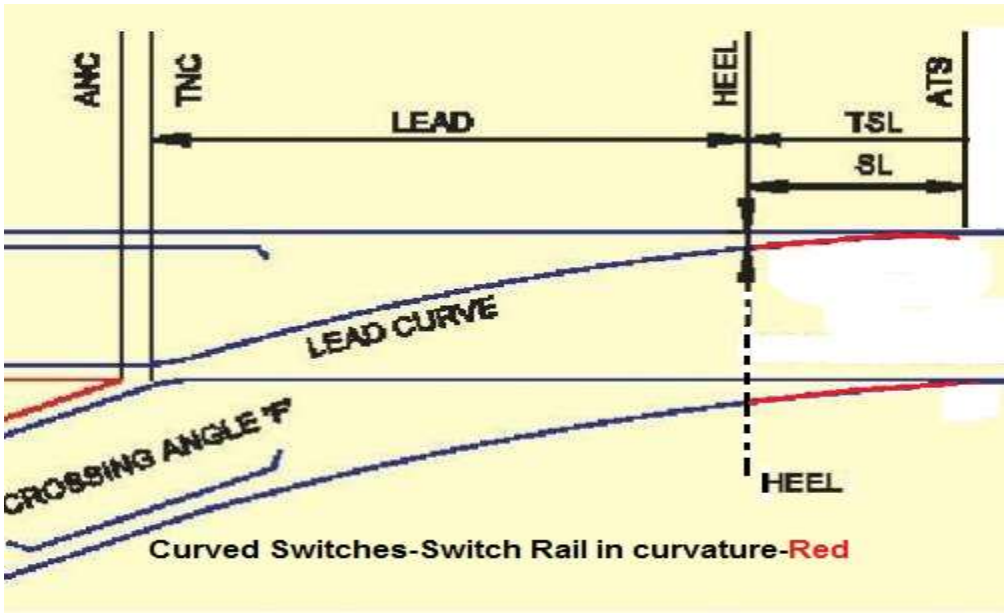


Diagram of Straight Switches (Switch Rail- Straight-Red)

Curved Switches



In this case tongue rail is curved (manufactured) in a curvature of turnout from TOS to HOS resulting smoother entry of trains in turnout. But there is the disadvantage that these can be used only for a particular curvature of left or Right Turnout.

CROSSING

Classification of Crossing:

The Crossings are classified in following two aspects:

1. .Based on Crossing Angle(Track Condition)
2. Based on methods of manufacturing

Based on Crossing Angle:

On basis of Crossing Angle the crossings are classified in three types

1. Acute Crossing / V- Crossing
2. Obtuse Crossing / Diamond Crossing
3. Square Crossing

Acute Angle Crossing:

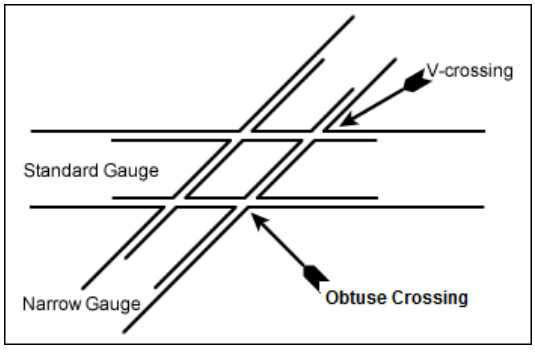
An acute angle crossing or V-crossing is that in which the intersection of two gauges faces (gauge line of pieces) forms an acute angle. In Indian Railway, acute angle crossing is used for all turnouts and cross overs.

Obtuse Angle Crossing:

Obtuse crossing is that crossing in which the two gauge faces meet at an obtuse angle . OR

When gauge faces or gauge line of a crossing intersect each other in such a way that angle between it forms an obtuse angle,the crossing is called obtuse angle crossing.

Since this type of crossing is only used in c so known as Diamond Crossing.



Square Crossing:

It is formed at the locations were two tracks cross each other at right angle.

Because of unguided/Unchecked/ Unprotected flange moment at the nose(due to non provision of checkrail), there are chances of derailment are more. Hence use of this type of crossing in Indian railway is not in practice.

Based on method of Manufacturing:

In this basis of methods of the crossing is classified into two

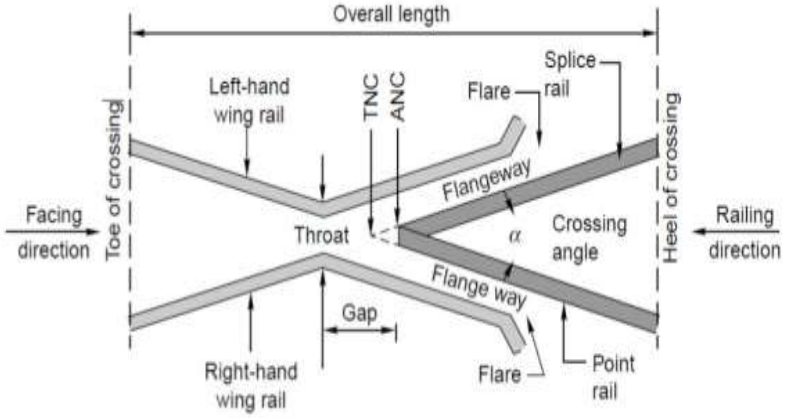
1. Built Up Crossing
2. Cast Steel Crossing

Built up Crossing:

In this type of crossing two flared wing rail and one nose or V-piece (combination of point & Splice rail) are connected by means of iron distance blocks ,nut and bolts.

This type of crossing is broadly used on Indian Railways. The major advantage of this type of crossing is

I. Initial fabrication cost is low.
II. Wear can be repaired at site without replacing the crossing.



Cast Steel Crossing (Cast Manganese Steel Crossing):

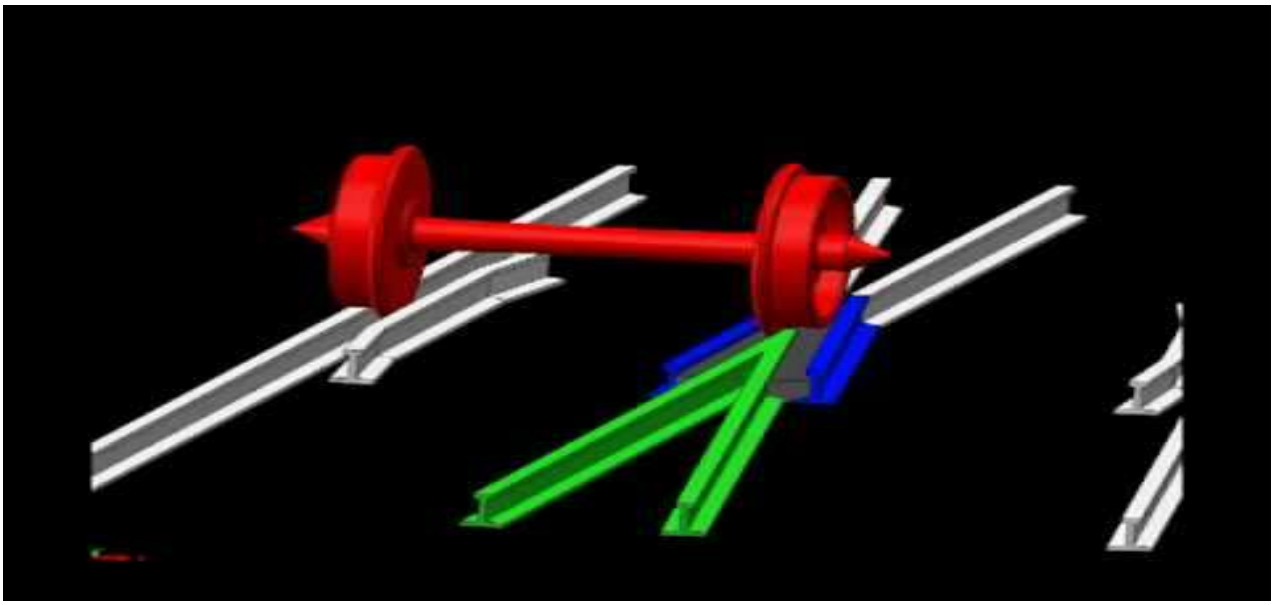
This type of crossing is manufactured by casting process in one piece

In this Series / Type of crossing, CMS(Cast Manganese Steel) crossing is adopted by Indian Railway and it is standard crossing for modern high speed track/Fan Shape turnout.

Advantages of CMS Crossing ;

1. It is more rigid crossing in one mass and having no loose parts like bolts, nut etc:- resulting it needs very little maintenance as well as very low maintenance cost .
2. Although the initial manufacturing cost of crossing is high but due to its metallurgical composition (having high manganese percentage) and manufacturing process. It has very good anti-wear capacity even under heavier axle load.
3. Due to its chemical and physical properties it has very long life and about four times in comparison to ordinary built up crossing.
4. Very useful on heavy traffic density routes where traffic block margin is very less.

Check Rail Clearance



The equation for finding check rail clearance is as under:

Check Rail Clearance = Track Gauge – (Wheel Gauge + Wheel Flange Thickness)

For New wheel: Check Rail Clearance = 1676-(1600+28.5) = 47.5≈ 48 mm

For Old Wheel: Check Rail Clearance = 1676-(1600+16) = 60 mm

It means the check rail clearance for new profiled wheel should be 48mm and maximum worn-out wheel it should be 60mm. if we will provide

46mm clearance, then old wheel worn out will hit check rail ends and if provide 60mm clearance, then new wheel will hit the nose of crossing.

Hence to overcome above problem 48mm clearance is provided in checkrail and to avoid hitting of check rails. Check rail and wing rail ends are given flared. So that entry of wheel in check rail will be smooth and easy without check rails end hitting.

To give wear out margin and to avoid frequent adjustment in CRC the check rail clearance in BG recommended as

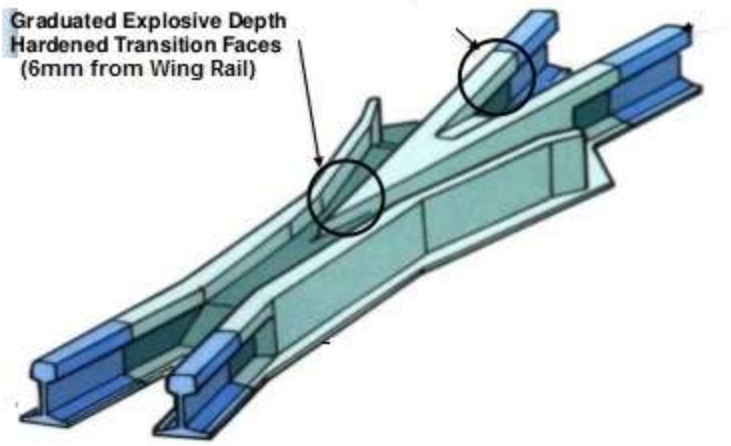
Minimum = 44 mm

Maximum = 48 mm

Note

1. Instead of giving flare in Check rail / wing rail now-a-days the checkrail is planned in such a way so that the end clearance must be more than 60mm. this designed is specially given with CMS crossing.
2. As per equation of clearance, the track gauge is very very important figure. Hence gauge in crossing portion must be very correct. Otherwise, slack or tight gauge will have adverse effect as explained above.

Ramping of Nose of Crossing:



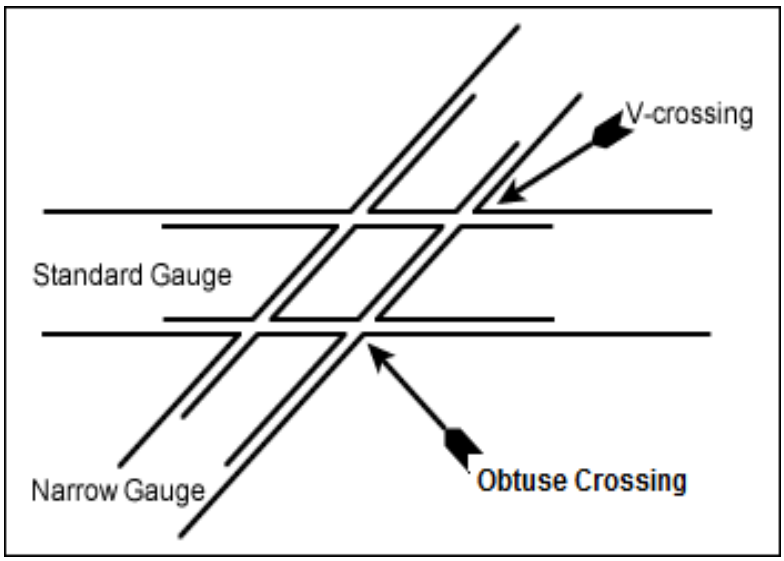
If we will trace the wheel path at crossing while moving on facing direction, we will see the contact area from wing rail is reducing and after a gap, contact area on nose is increasing suddenly.This results in heavy wear in crossing nose. Coning of 1 in 20 in wheel is also responsible for it(wear).

If nose piece will be in same level of wing rail, after arrival of wheel on nose piece from a gap and wing rails, sudden total load will impact on nose. Since thickness of nose is very less, the chances of cracking/breaking of nose is more.

To avoid this level of nose piece is kept 6mm down from wing rail level and leveled after the distance of 90mm. so that load will be impact on nose piece after achieving sufficient head thickness.

DIFFERENT LAYOUTS OF YARD

Diamond Crossing (Layout):



When two tracks cross each other at a particular angle. The diamond is formed. These two tracks may be of same gauges or different gauges.

Note: The diamond consists of two acute crossing and two obtuse crossing

Limitation of intersecting angle of diamond crossing:

As per schedule of dimension (SOD) in IR, diamond crossing flatter than 1 in 8 ½ should not be laid. The reasons are following:

1. In diamond crossing, when wheel passes from point rail to elbow or vice-versa, it crosses an unprotected gap (of obtuse crossing). In 1 in 8 ½ diamond crossing the gap is less and as well as crossing will become flatter, this gap will increase. Hence to avoid longer unprotected gap, there is restriction to use diamond crossing flatter than 1 in 8 ½ .
2. When intersecting angle will reduce the obtuse crossing of diamond will have tendency to come in front of each other in respect to wheel moment.

This is dangerous condition and chances of derailment are more. So that there is a restriction in use of diamond crossing flatter, than 1 in 8 ½.

Provision of Strip On Check Rail Of Obtuse Crossing

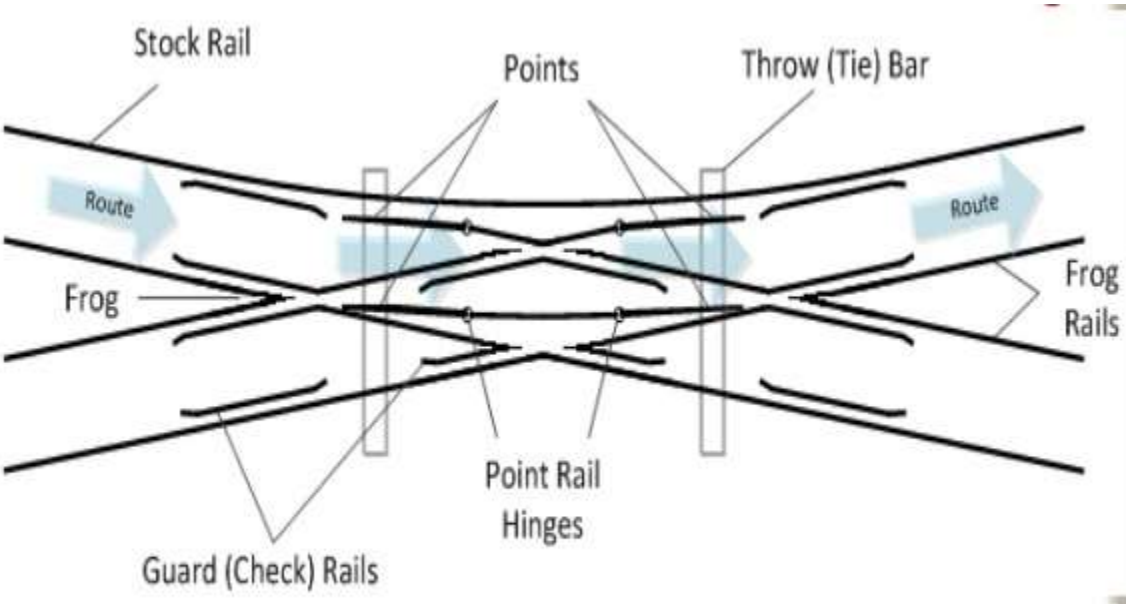
Unprotected gap of obtuse crossing in 1 in 8 ½ diamond is less and wheel passes on it with momentum in few seconds only.

But if the train/vehicle is stopped on it in such a way so that wheel is in the gap or near to gap and when train will start, the wheel will be subjected under jerk and due to this there are chances with wheel to take wrong path , resulting derailment on diamond crossing, There are so many derailments on diamond crossing like this specially with pony wheel of locomotive.

To overcome above problem, the check rail of obtuse crossing is welded with 25 mm thick steel strip for raising height. This welded strip reduces the unprotected gap as well as chances of derailment by protecting properly

Strip more than 25mm is not allowed because of there are chances of infringement of locomotive parts.

Diamond With S



Slip is an arrange
diverted from one

If we will use on
diamond with sir
point then it will

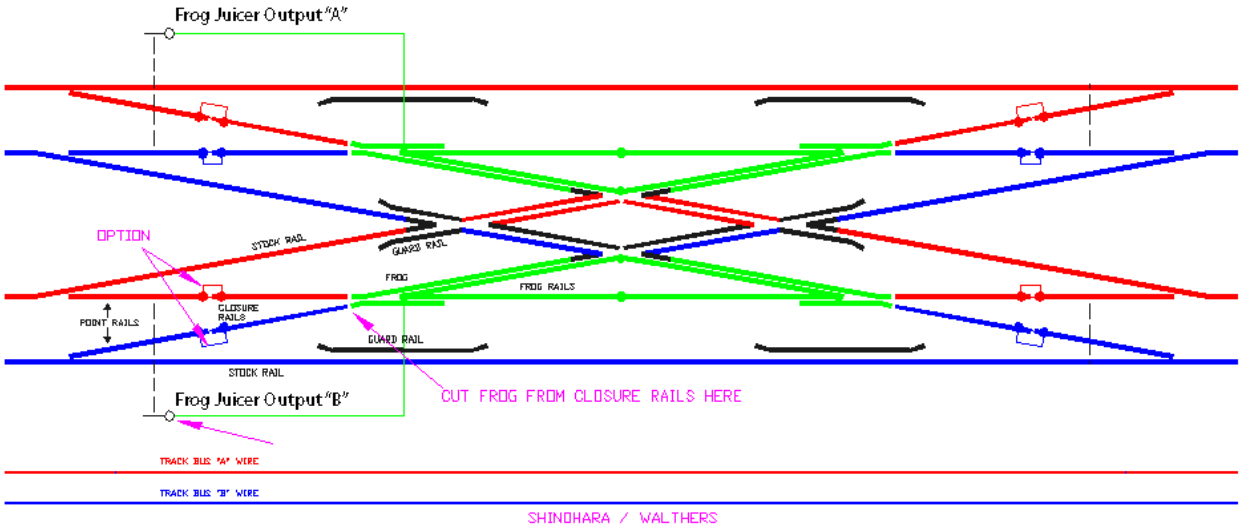
Diamond Crossing with Single Slip

Cross Over

Cross over is a layout which is used to connect two

through track. It has two turnout which are connected with each other by intermediate portion.

Scissor cross over:



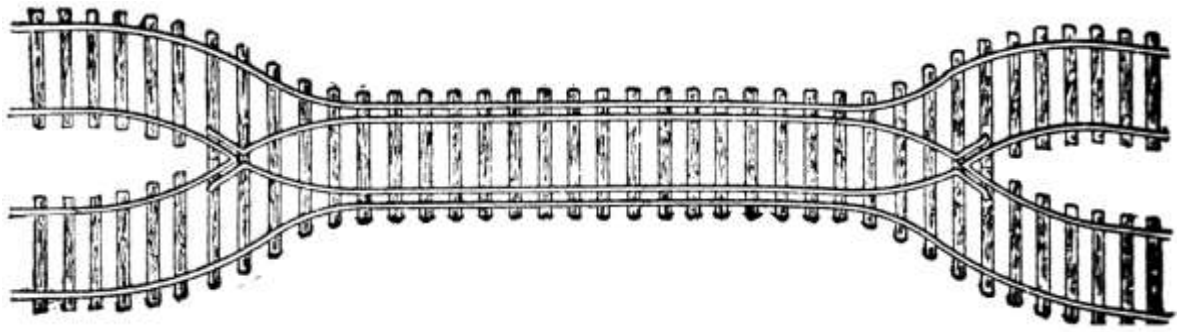
When two cross-overs intersect each other then complete layout is known as scissor cross over.

The scissor cross over is provided for a transfer the vehicle from one track to another and vice-versa. It is provided at the location where space does not permit for provision of two separate cross over specially in long platform lines.

Scissor cross over is consist of

1.Four set of turnout
2.One set of Diamond

Gauntleted track



(Line diagram)

When two tracks pass over on same formation and sleeper the layout is named as gauntleted track. This track may be same gauge or different gauge

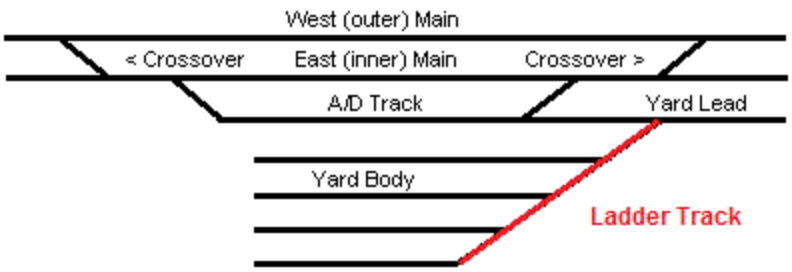
This is temporary diversion provided on double line track so that one of the track is shifted and passes through another on same sleepers.

It is useful connection where one side of the bridge or double line section is required to block for major repair or re-building.

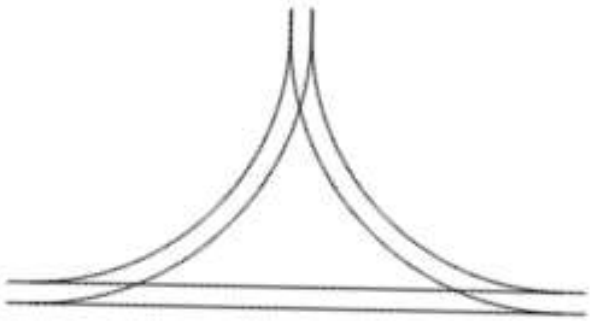
Gauntelled track is also used where trains have to operate on mixed gauge say BG and MG.

Gathering line/Ladder track

Gathering line is a slopping line in which number of parallel tracks gather or merge or branched off. This layout is very very useful in yard section.



Triangle Layout



When three turnouts are laid on straight track or on curve track in such a way so that the a triangle is formed in between, layout is called Triangle Layout. This is a substitute of turntable. But it has a disadvantage that it needs a longer space but maintenance of it is easy and cheaper.

RESTRICTION IN USE OF 1 IN 8 ½ TURN OUT IN PASSENGER RUNNING LINE

Restriction in use of 1 in 8 ½ turn out in passenger running line is restricted due to the following reasons:

Whenever a 1 in 8 ½ turnout is provided in passenger line, its turnout angle will be more and its "turn in curve" will be sharper. Due to engine flange force, turn in curve" will become more sharper. When a passenger train enters in a loopline by a speed more than the prescribed speed, chances of derailment on it will become more.

1. Keeping in view of this Railway Board issued a direction that in passenger running line, only 1 in 12 turn out will be used.
2. Untill the removal of 1 in 8 ½ turnout from passenger running lines, there will be a speed restriction of 15 kmph on it.(Now a days it is 10Kmph)
3. Speed restriction on turnout will be as following

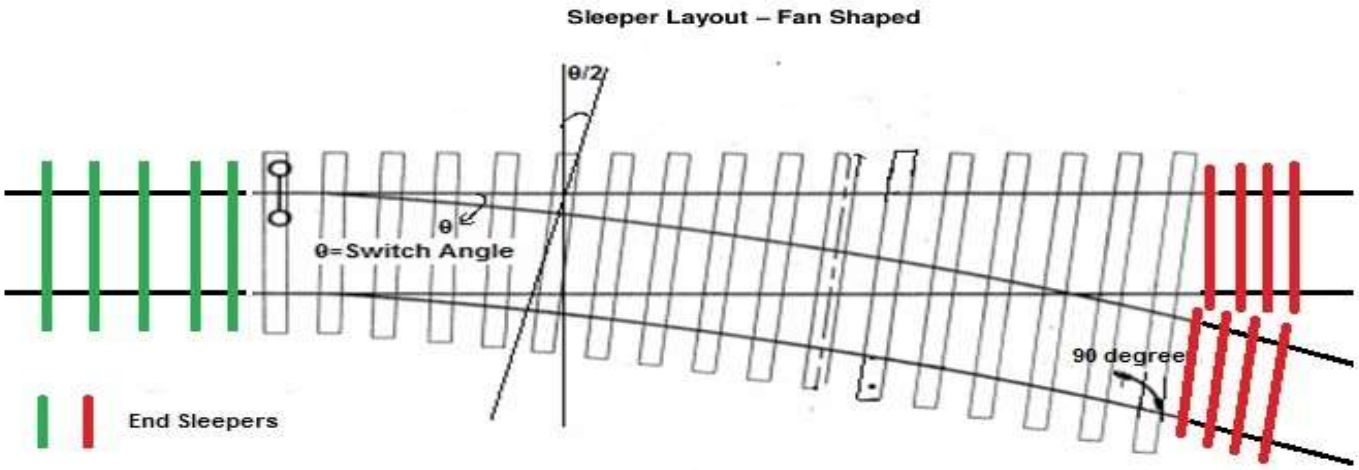
1	1 in 8 ½ Turn out	Curved/Straight Switch	15 Kmph
2	1 in 12 turnout	Curved/Straight Switch	30 Kmph
3	1 in 8 ½ turnout	Symmetrical split curved switch	30 kmph

Important Notes for Point and Crossings:

1. No gradient will be provided in approaches of turn out upto 30 metres.
2. If contrary split switch is provided in any turnout , then speed restriction will be 10 kmph.

FAN SHAPED TURNOUT

Special Features:



S.No.	Turnout→	1 in 12	1 in 8 1/2	Sleepers' Positions
1.	Sleeper no	1-20	1-13	switch sleeper-perpendicular to mainline track
2.	Sleeper no	21-65	14-41	Lead sleeper- at angle of Θ/2 from main line, where Θ=Switch Angle.
3.	Sleeper no	66-83	42-54	Crossing sleeper- perpendicular to crossing turnout track.

1. The position of Switch sleeper will be perpendicular to mainline track
2. The position of sleepers on lead curve will be at angle Θ/2 from perpendicular drawn on mainline from that point. Where Θ is the angle between main line. Tangent drawn to lead curve through the point.
3. The position of Crossing sleeper will be perpendicular to crossing turnout track.

Note :

Top view of this turn out looks like a fan (Hand fan), hence this turn out named as "FAN SHAPED" Turnout .

Advantages of Fan Shaped Turn Out:

1.Complete one set of sleeper can be used for both types of turnout i.e. left & right, resulting to avoid unwanted inventory confusion.

2.It provides heavy, strong and robust type track structure due to PRC sleepers. Hence its lateral and longitudinal stability is very good.
3.Same set of sleepers can be used for 52kg and 60 kg rail section. Only with changing of the liner
4.CMS Crossing for different type of rail section (52kg and 60 kg) has identical footing.
5.Comparatively longer switch are used resulting smooth entry of trains on turnout side.

Laying:

1. **Number of sleepers**

Turn Out	Approaches End Sleeper	Turn Out Sleeper	Total Sleeper
1 in 8 ½	13(5+8=13)	54	67
1 in 12	13(5+8=13)	83	96

Note:S-Signal sleeper at motorized point for motor installation.

2. **Precaution**

MFG DATE 60 KG	RE

RE mark should always be kept in right side while laying whether it is right hand or left hand turnout.

3. **Important Dimension of Fan shape Turn Out**

DIMENSIONS	1 in 8 ½ in mm	1 in 12 in mm
Stock Joint Ahead Distance	1500	1144
Switch Length	6400	10125
Lead	18395	25831
Radius	232260	441360
Over All Length	28613	39975
Switch Angle	46°59”	0°20’0”
Length of Tongue Rail	7620	12356
Length of Stock Rail	12800	13000
Length of CMS crossing	3300	4350
Heel Divergence	182	175

Handling Of Turnout Sleepers:

1. Switch and approach sleepers shall be loaded on BFR-perpendicular to track.
2. Lead and Crossing Sleepers-shall be loaded on BFR-along the track.
3. Wooden batterns shall be provided between two layers of sleepers-to avoid damage of sleepers.
4. Loading and unloading shall be done preferably by Crane.
5. Do not throw one sleeper on another.

PROTECTION

PATROLLING

The following are the types of patrolling in terms of track :

1. **Keyman's daily patrol.**

In every morning every inch of track to a certain distance is watched by a keyman for any damaged (or) missing parts of the rail fastenings like pandrol clips, liners, fish plates etc.

2. **special situations like**
    a. At the time of civil disturbances
        a. Internal disturbances
        b. External disturbance
    b. At the time of VIP movement
3. **Monsoon patrolling**

This is done during Monsoon Season

a. Stationery Patrolling

This is done on standard points where the track invent/that may dend to wear very soon

b. Mobile Patrolling

4. **Hot weather patrolling**
5. **Cold weather patrolling**

DAY: It is defined as the time between sun rise and sun set

NIGHT: It is defined as the time between sunset and sun rise

Engineering Work : The work related with tracks like Maintenance, New laying etc are known as Engineering Work. Normally engineering work should not be carried out in night

1. **Short Duration Works:** The work which are carried out only in one day.E.g.- Rail Renewal, TTM working, Welding Etc.No night involves in it.

2. **Long Duration Work :** The work which are carried out in two days (or) more than two days including atleast one Night or more.For example- Major bridge repair,deep screening etc.

ENGINEERING INDICATORS:

Engineering Indicators

Temporary Engineering Indicators | **Permanent Speed Restriction Indicators**

i) CautionIndicator.

ii) SpeedIndicator.

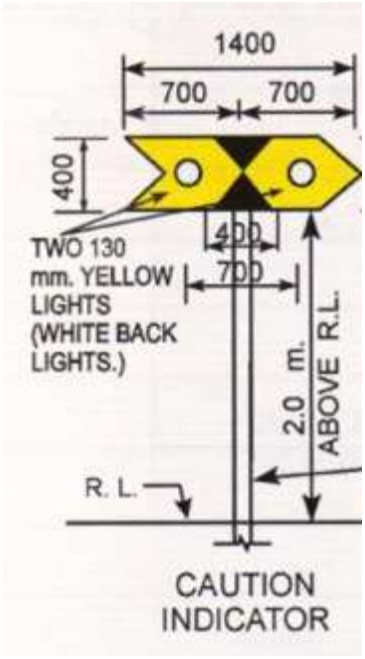
iii) StopIndicator.

iv) Termination indicators (T/P & T/G).

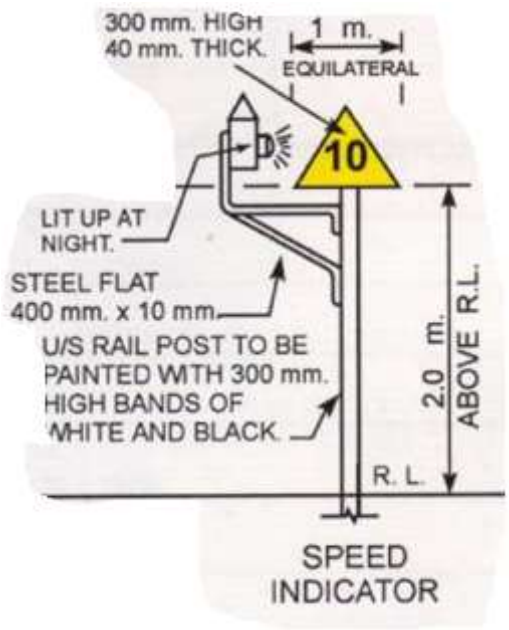
Temporary Engineering Indicators:

These indicators are used in connection with execution of some engineering work and removed as soon as the work is over. These indicators are flood lit at night. Retro-reflective indicators need not to lit at night. Significance of each indicator is given as below:

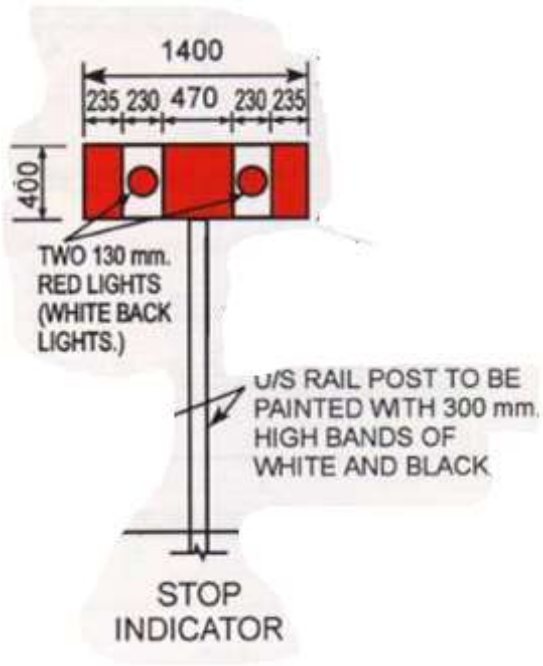
(i) Caution Indicator – This cautions the driver to get ready to reduce the speed. Caution indicator shall be provided at 800m in rear of the speed indicator and at 1200m where the trains are required to stop dead as in this case more braking distance is required by driver. This shall consist of 1400mm long, 400mm wide. Fish tailed at one end and pointed at the other having 130mm dia holes 2 nos. for showing yellow lights at night . The board shall be painted yellow & black. Height of the board (bottom of the board) shall be 2.0M from rail level post will have 300mm high bends of white & black. Indicator shall be used in case of permanent as well as temporary restrictions. Temp. Engg. Indicator shall display at night 2 yellow lights to approaching trains or provided with fluorescent tape luminous paint or retro-reflective indicators (need not to lit at night).



ii)Speed Indicator – It indicates to the driver to reduce the speed as indicated. This shall be provided 30M in rear from the point of commencement of speed restriction. Indicator shall consist of an equilateral triangular board with 1 meter sides having yellow base, 300mm high and 40 mm thick figures in black indicating the speed at which the train may proceed. The board shall be provided on a 2.0m high post (from the rail level to bottom of the board) painted with 300mm high white and black bands Indicator shall be illuminated at night by fixing a hand signal lamp in front of it or provided with luminators.



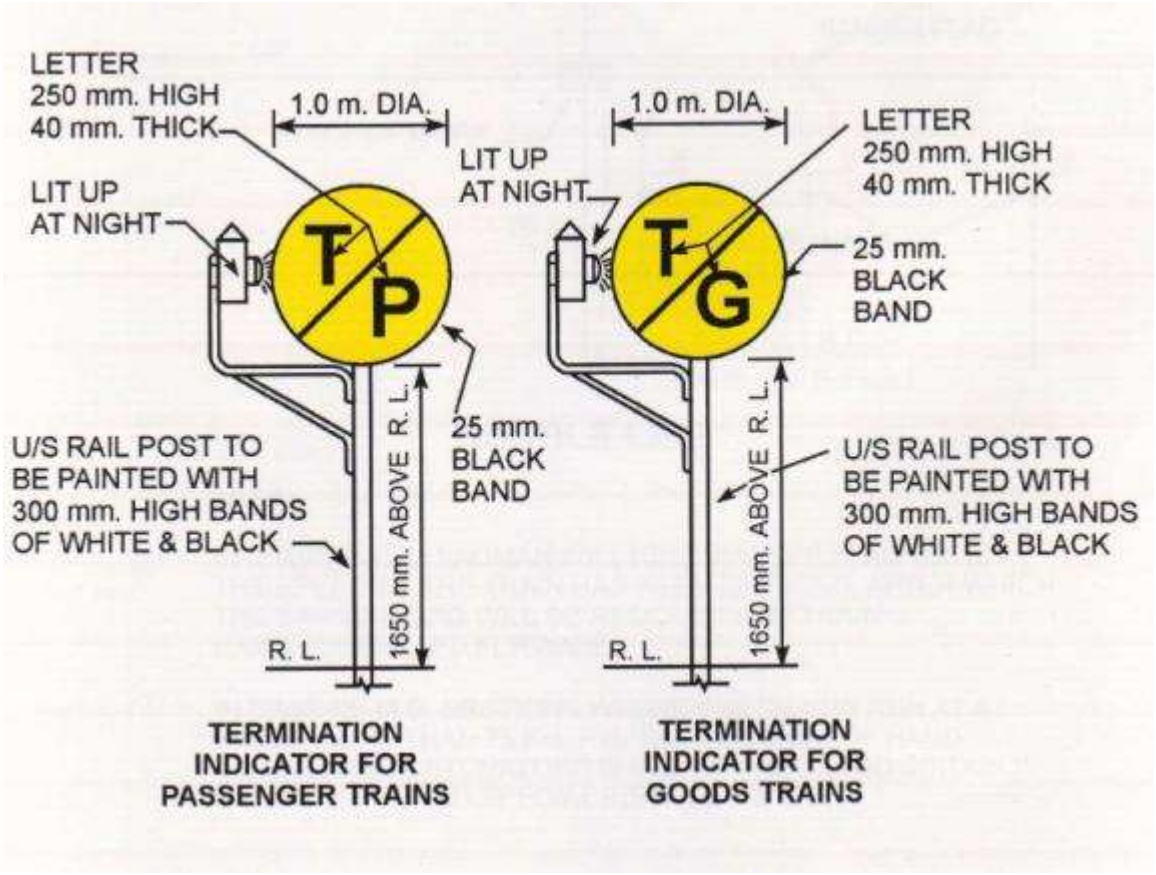
(iii) Stop Indicator – It indicates to the driver to stop the train short of indicator. Indicator shall be provided 30m m in rear of the commencement of stop dead restriction. This shall consist of a rectangular board 1400mm x 400 mm in size having 130mm dia holes 2 Nos. for showing red lights at night painted with red and white vertical strips or provided with fluorescent tape luminous paint or retro reflective indicator. The board shall be fixed 2.0 meter high from rail level to the bottom of the board) painted with 300 mm high bands of white & black.



(iv) Termination Indicator – The indicates that the driver to resume normal; speed and last vehicle has cleared the restricted zone. This indicator shall be fixed at a distance equal to the longest length of passenger/goods train running in the section beyond the restricted zone.

The indicator shall be in accordance with the diagram &shall consist of one meter dia disc painted yellow bearing 250mm high and 40mm thick letter T

P and T.G. in black. The board shall be painted with 25mm thick black band at the circumference. It shall be fixed on a post 1650mm high (from rail level to the bottom of the disc) and shall be painted with 300mm high bands of black & white. The indicator shall be lighted at night by a fixed hand signal lamp or provided with fluorescent tape luminous paint or retro reflective indicator.



PERMANENT SPEED RESTRICTION INDICATORS:

(i) These indicators are same as mentioned above but used at the locations requiring permanent speed restriction (less than maximum sanctioned speed) such as weak bridge, sharp curve, weak formation turn out etc. As these restrictions last beyond the currency of the working time table hence mention of such restrictions are made in the working time table. Indicators provided are not lit at night.

(ii) Siding Boards – Siding boards indicating speed restriction are provided at facing of an outlying siding letter 'S' is painted in 300 mm height with black paint on 1 metre dia circular board having yellow base. These boards are provided in addition to caution & speed indicator where maximum sanctioned speed of the section does not exceed 59 kmph.

Indicators (General):

These indicators are provided either to give audible warning by the driver to ensure safety or shunting operation.

Whistle Indicator (W):

Whistle Indicators shall be provided at 600 m in rear of the places where the view of driver is obstructed by cutting or tunnel or curves and where it is necessary to give audible warning at the approach of a train to those working on the track.

Whistle Indicators for Level Crossing (W/L):

These indicators shall be provided at the approaches of all unmanned 'C' class level crossing or manned level crossing where the view is not clear on either side for a distance of 600 metres and those which have normal position open to road traffic. Bilingual whistle boards shall be provided at 600 m distance along the track from the level crossing to give audible warning by the drivers of approaching trains to the road users.

Shunting Limit Boards:

A rectangular yellow board(600 x 1000 mm) with a black cross at the top and the words 'Shunting Limit' (or 'S/L') indicates the end of a shunting section. This sign normally also has black and white bands on it, and white lamps attached on both sides (although the words are only on the side towards the station). This is usually provided at class 'B' stations on single-line sections (sometimes double-line) where shunting is permitted on the block section and advanced starters are not provided.

The sign is placed 400m to the rear of the first stop signal of the station in lower-quadrant signalling (180m in modified lower-quadrant, upper-quadrant, and MACL systems). A single white lamp may appear through a hole in the sign above the centre.

Works at Times of Poor Visibility:

No work which may cause obstruction to the passage of train shall be undertaken during foggy or tempestuous weather impairing visibility except in case of emergency. When such works are undertaken 2 detonators, 10 m apart shall be fixed 270 m in rear of caution indicator and caution hand signal exhibited to approaching trains.

Speed Restriction:

In case where the trains are required to pass with restricted speed from site of work, the following temporary Engineering Indicators shall be exhibited.

(i) Caution Indicator – At 800m in rear of the obstruction.

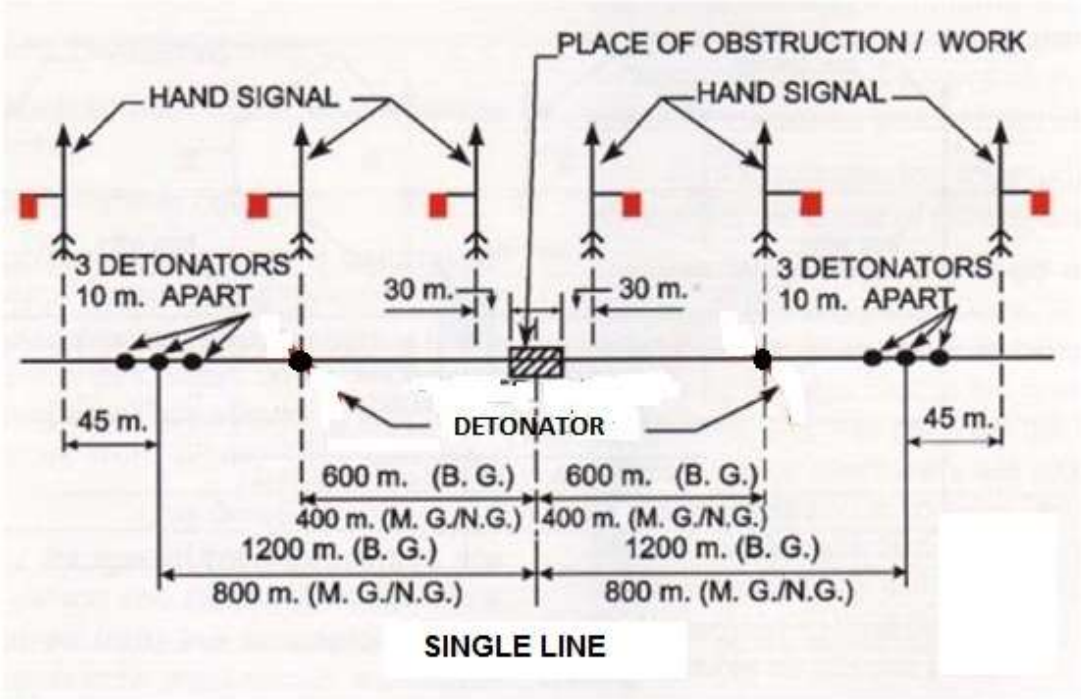
(ii) Speed Indicator – At 30m in rear of the obstruction.

(iii) Termination Indicators for passenger & goods train – At a place from where the driver may resume normal speed, which is the length of longest passenger/goods train running in the section.

PROTECTION

1. Protection During Emergency
2. Protection During Short Duration Work
3. Protection During Long Duration Work
    i. When stop dead & 10 KMPH is required
    ii. When only speed restriction is required

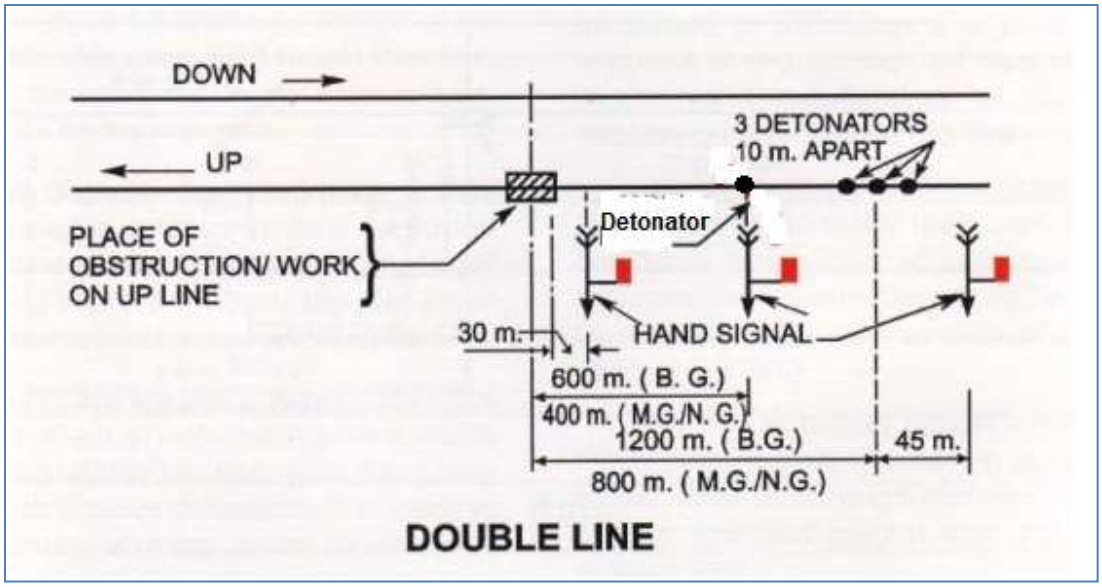
Protection During Emergency:



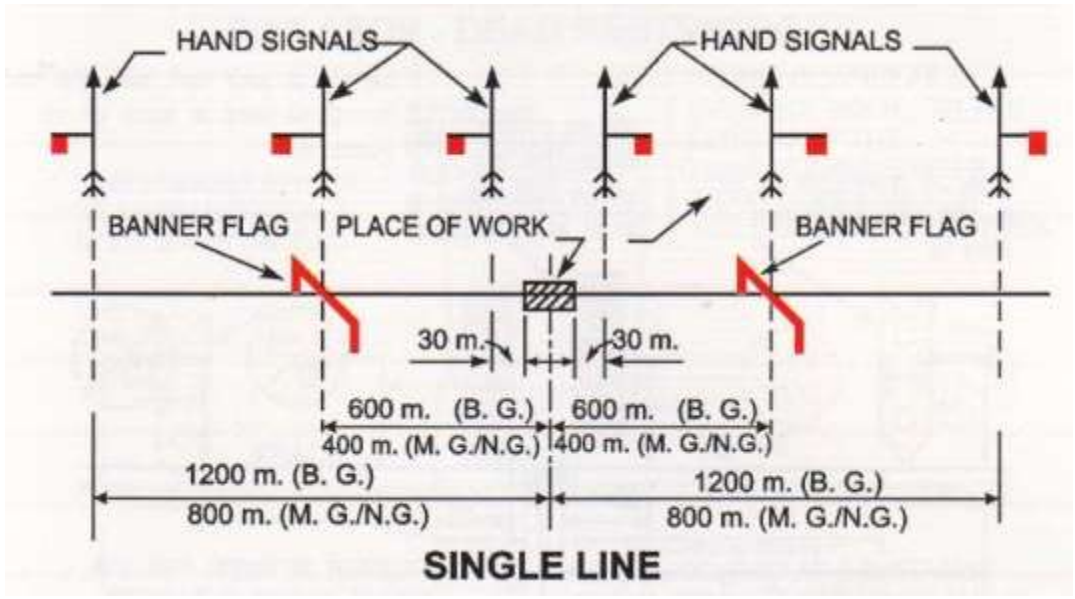
Key Man Having (1). 6Nos of detonators (2) 2 Red flag & 1 Green Flag

Note :

1. Red hand signal Flag (HS Red Flag) for day and Hand signal red lamp is considered as a danger signal.
2. All distances should be measured from the danger zone
3. Single line protection will be made in both direction and in double line protection will be made in direction from which the train as to come.
4. In case of emergency concerned railway person will take his own decision to stop the train in any how before reaching the danger zone .

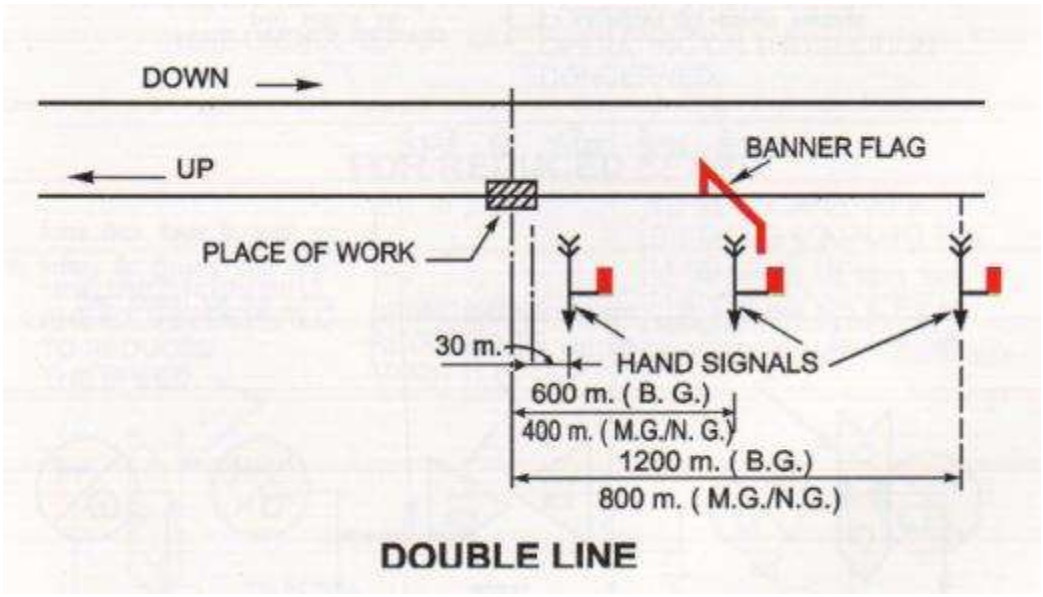


Protection during short duration work (In single Line BG Track)(6 Flag men used)

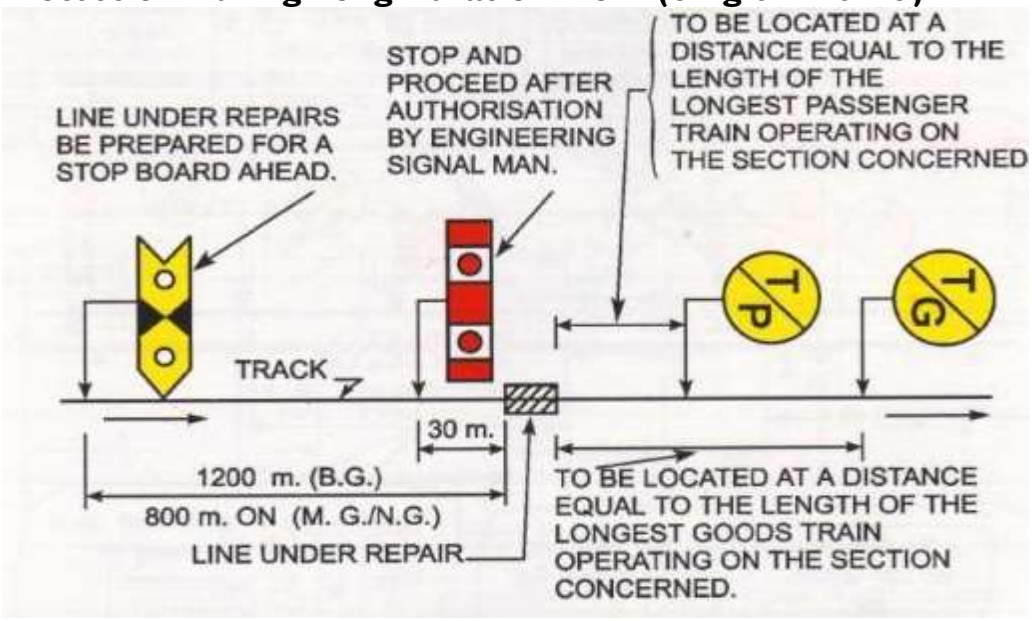


Note:

1. In this protection red banner flag is considered as a stop signal
2. In this protection 3 flagmen required in one side(single line- 6flagmen , Double line 3 Flagmen)
3. In single line protection will be made in both direction and in double line protection will be made in 1 direction
4. In case of TTM working these flagmans will also be mobiled keeping the standard distance as maintained



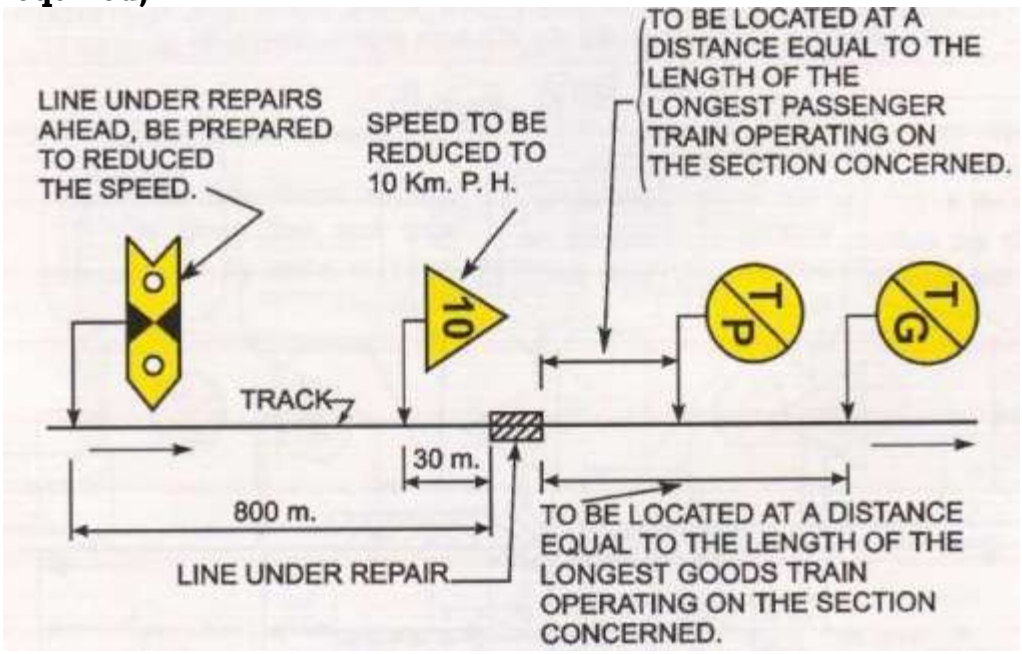
Protection During Long Duration Work (Single Line BG)



Note:

1. For long duration work protection of track is carried out with the help of caution board etc
2. During night each board will be manned and lighted only stop dead board will be equipped with a stationery patrolman (round the clock) with patrol book.
3. After passing out the train the entire danger area will be inspected by stationery patrolman and If found satisfactory then only next train will be permitted to pass out on danger one with the speed of 10 KMPH
4. All the distances shall be measured from danger zone.
5. During day H.S. Red flag & during night H.S Red Lamp is considered as danger signal.

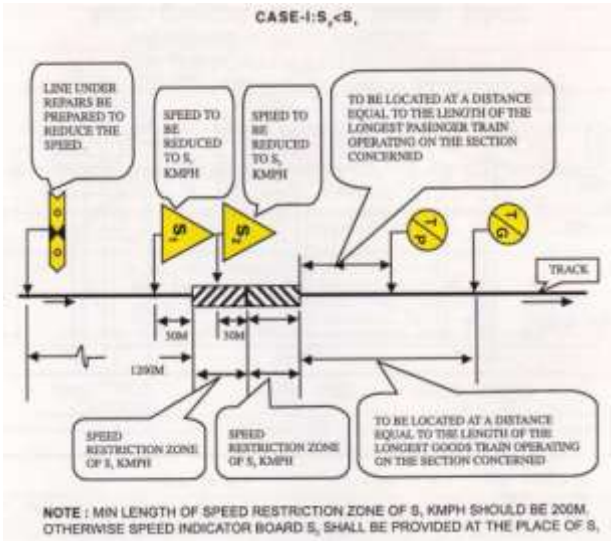
Projection During Long Duration (When Speed restriction only required)

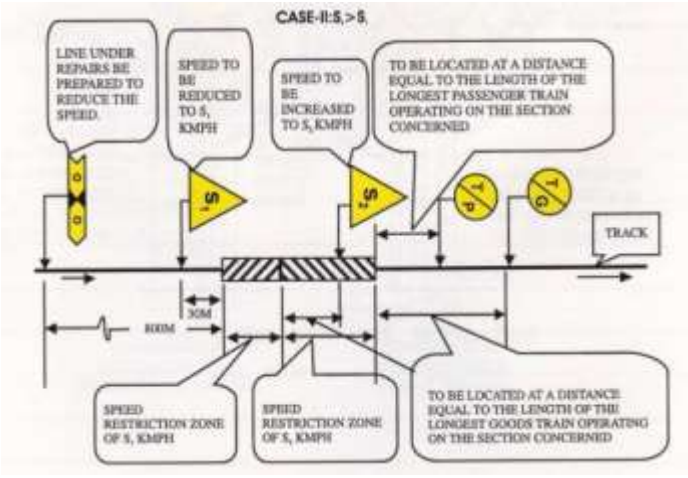


Note:

1. During day no patrol man is required.
2. In night all board will be ignited
3. During night patrolman is required
4. All dimensions should be measured from danger zone
5. Speed restriction depending upon track condition.

POSITION OF ENGINEERING INDICATORS IN CASE OF MULTI SPEED RESTRICTIONS





ACCIDENT

Accident:

Any unpleasant event which affects the normal operation of trains or any casualty or loss of property is known as an accident.

Serious Accident:

If there is any casualty or serious injury or loss more than Rs 2 crores or all is/are involved, it is known as serious accident.

Collision:

When vehicles hit each other is known as collision.

Averted Collision:

When vehicles are going to collide but collision does not happen and the distance between them is less than 200 meters, it is known as averted collision.

If the gap is more than 200 meters, it is known as **Breach of Block Rules**.

Classification of Accidents:

S.No.	CLASS	DESCIPTIONS
1	A-Class	Collision of Trains.
2	B-Class	Fire in train, when casualty or damage more than Rs 5000.
3	C-Class	Gate accidents (train running to the road traffic or vice versa)
4	D-Class	Derailment.
5	E-Class	Other train accidents like collision of trains by the fixed structure.

6	F-Class	Averted collision.
7	G-Class	Breach of block rules.
8	H-Class	Train passing danger signal.
9	J-Class	Train parting, failure of engine or failure of rolling stock.
10	K-Class	Failure of p-way like fracture, breach.etc
11	L-Class	Failure of the electrical equipments(when the failure time is more than 3 minutes)
12	M-Class	Failure of the signal and telecommunication(when the failure time is more than 10 minutes)
13	N-Class	Sabotage as breaking in trains etc.
14	P-Class	Casualties, injuries.
15	Q-Class	other incidents like robbery in train, murder or agitation.
16	R-Class	Miscellaneous.

Sounding of the Hooters:

1.Long Hooter- 30 seconds(It indicates the gravity of accident.)
2.Small Hooter- 5 seconds(It indicates involvement of injury/ casualty)

Accidents and corresponding Hooters:

S.No.	Hooter's Sounding Pattern	Description of Accident
1	Two long — —	Accident in the locomotive shed or traffic yard adjoining the locomotive shed
2	Three long — — —	Accident at the out-station where the main line is clear
3	Three long and one short — — — o	Accident at the out-station where the main line is clear and the relief train is to be accompanied by the medical car
4	Four long — — — —	Accident at the out-station where the main line is blocked and the relief train is not accompanied by the medical car
5	Four long and one short — — — — o	Accident at the out-station where the main line is blocked and the relief train is to be accompanied by the medical car

ART Timings:

1. ART(Accident Relief Train) proceeds within 30 minutes (day time)/45minutes(night) after the sounding of hooters.
2. Medical Van proceeds within 20 minutes (day time)/30minutes (night) after the sounding of hooters.

Actions Taken by Engineering Officials during accident:

The first engineering official to arrive at the site of the accident should take the following actions:

1. **Take steps to protect the train.**
   First of all accident site must be protected with temporary engineering signals either by train guard/drivers or engineering officials. In double line, if another line is also affected-it must also be protected.

2. **Coordinate first aid and rescue efforts.**
   The official should arrange medical aid to the injured passengers and railway staffs and rescue to the trapped passengers. If there is any medical practitioner on the train his assistance should be obtained.

3. **Examination of the entire accident site.**
   Examine the entire site and train for any unusual feature specially any part of the vehicle or other material lying near the track.

4. **Advice the nearest station master.**
   After the rapid survey of the position ,particulars and aids(help) required should be reported to the nearest station master or sectional controller.
   If the cell phone is available its help can also be taken.

5. **Carry out a detailed examination of the site.**
   Carry out the detailed examination of the site like wheel marks on the rail head, condition of the track components and initial mounting/derail point of the wheel.

6. **Draw a dimensional sketch of the site giving full details.**
   Prepare a dimensional sketch giving the full particulars of the site including point of mount/point of drop etc.

7. **Collect and preserve any clues pertaining to the accident.**
   Preserve Clues of evidence of wheel marks specially at the point of mount drop or any such clues which may help in analyzing the cause of accident.

8. **Record the track geometry.**
   Track geometry and its parameter shall be measured and recorded in presence of other departmental officials and with their signatures.

9. **Vehicle Measurement**
   Record the detail of IOH/POH of the vehicle, its different measurements as prescribed and any deficiencies like break blocks etc and

broken/hanging parts of the vehicle like springs etc jointly with other departmental representative.

10. Examine the operating features.

Investigate and record of various features such like speed, train formation(marshalling),loading condition, point and lever setting position of signal and other factors which might contribute the derailment.

11. Examination of the Gang Chart

The gang chart should be examined to know the date of last attention of the site.

12. Prepare a preliminary report.

Make Out a preliminary report that contains the following information:

1.The nature of accident.
2.Cause if known
3.Particulars of loss of life, injuries to passengers and staff.
4.Extent of damage to way and works.
5.Steps Taken to resumption of traffic.
6.Probable date and time when normal working is likely to be opened.
7.Whether transshipment is necessary and if so ,when it is likely to be opened.
8.Details of any assistance required, such as additional labour,ballast,train bridging material etc.
9.Follow up Action: Take action to collect men and material to repair the track and restore the traffic.

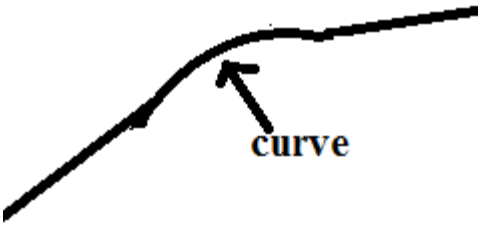
Assam train derailment

KAMAYANI EXP DERAILMENT -hit by Bombay Janta Exp Coming on adjacent track at Harda(WCR)

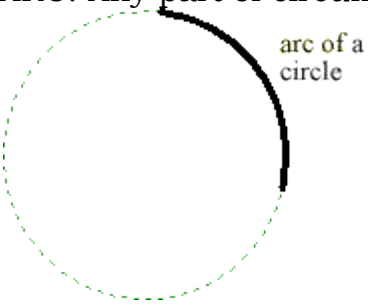
CURVE

Important Definitions: –

Curve: the geometrical 'ARC' provided at the change of Alignment or Gradient is known as 'Curve'

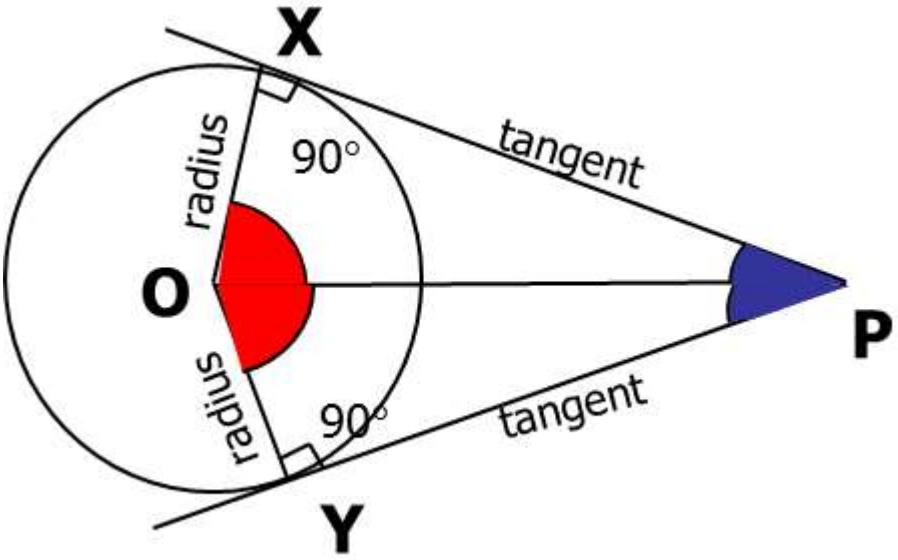


ARC: Any part of circumference of a cicle is known as ARC.



TANGENT:

It is the straight line which touches the circumference of a circle only at one point. It is always at right angle to the radius at the point of contact from any point outside the circle only two tangents can be drawn

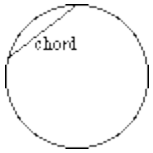


TANGENT POINT: It is the point of contact of Tangent and Circle

TANGENT LENGTH: It is a distance between the tangent point and point from the two tangents are drawn

Tangent Length (TL)= $R\frac{Tan\emptyset}{2}$ Where Ø = Defect angle

CHORD : It is a straight line joining the two points of the curve



SHORT CHORD: In Indian railways (Particularly in high speed) 20 mtrs Length of Short Chord is considered as standard for track geometry measurement.

LONG CHORD: It is a straight line joins the two tangent point of a curve.

APEX: it is the highest point on the curve which is also at middle of the ARC.

APEX DISTANCE: it is the distance between intersection points of the tangents and middle of the Arc.

DEFLECTION ANGLE: it is angle through which the curve turns. It is taken as external angle between intersection points of two tangents.

INTERSECTION ANGLE: It is the internal angle of two intersecting tangents.

TANGENTIAL ANGLE: it is the angle which is formed by the long chord and tangent which is equal to half of the deflection angle.

Tangential Angle = ½ Deflection Angle.

Central Angle: An angle suspended at the centre of circle and equal to deflection angle of that are central angle

VERSINE: It is the perpendicular distance from the centre of the chord of 'ARC' placed on the chord

OFFSET: It is the perpendicular distance from the tangent to arc of circle

DEGREE OF CURVE:

A curve is defined either by its radius or by its Degree

Degree of curve (D) is the angle subtended by an arc of 30.5 m/100 feet length of curve at the centre of the same circle.

Since railway curves are very flat hence the degree of curve is also defined as the angle substended by a chord of 30.5m/100 feet at its centre is called "Degree of Curve".

Maximum Limit of the Curve in IR

1. Broad Gauge (1676mm) :- 10^0
2. Meter Gauge (1000mm):- 16^0
3. Narrow Gauge (762mm) :- 40^0

Relation Between Degree & Radius of Curve:

Since circumference of the circle/curve = $2\pi R$

Angle at the centre of the curve is 360^0

Therefore the angle subtended by 30.5m chord at the centre of curve can be worked out as follows

$2\pi R$ 360^0 $\longrightarrow$

$$\frac{2\pi R}{360^\circ} = 1^\circ$$

$$\frac{2\pi RD}{360°} = D°$$

Since arc length of 30.5m corresponds to D°

$$\frac{2\pi RD}{360°} = 30.5$$

$$D = \frac{30.5 \text{ x } 360°}{2\pi R}$$

$$D = \frac{1750}{R}$$

IF chord is given in feet then length of chord is 100 feet

$$\frac{D}{360°} = \frac{100}{2\pi R} \quad R = \frac{5729.58}{D} \quad D = \frac{5729.58}{R}$$

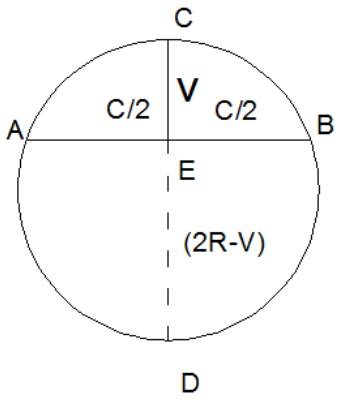
in F.P.S System

VALUE OF VERSINE IN TERMS OF CHORD:

Since property of curve we know that

AE x EB = CE x DE

C/2 x C/2 = V x (2R-V)



$$\frac{C^2}{4} = 2RV - V^2$$

Since the value of V is very low so V^2 is neglected

$$\frac{C^2}{4} = 2RV$$

$$V = \frac{C^2}{2R\ X\ 4}$$

$$\boldsymbol{V = \frac{C^2}{8R}}$$

Question:Find out the length of the chord in meters for which Versine in cm is Equal to degree of the curve

Given: Versine in cm = Degree of curve

To Find: Length of chord C in meter =?

Formula to be used

$$\boldsymbol{V = \frac{C^2}{8R}}$$

Let the chord 'C' and radius 'R' is in meter

Then $V = \frac{C^2}{8R}$

$V = \frac{C^2}{8R}$ X 100cm

$V = \frac{25C^2}{2R}$ cm

We know that $D = \frac{1750}{R}$

Since V= D

$\frac{25c^2}{2R} = \frac{1750}{R}$

$C^2 = \frac{1750 \text{ X } 2 \text{ X } R}{25 \text{ X } R} = 140$

$C = \sqrt{140}$

C= 11.8 mtrs

NOTE: It means Versine measured in cm on 11.8 mtrs chord length is equal to the degree of the curve

[FPS System = Degree of curve = Versine on 61.8 feet chord]

Numerical Problem:

1. Find out the value of degree of curve having following radius
   a. 1750 mtrs b. 825 mtrs c. 1000 mtrs d. 3500 mtrs

   Solution

   Formula Used : $D = \frac{1750}{R}$

   a. $D = \frac{1750}{1750} = 1°$

   b. $D = \frac{1750}{825} = 2°$

   c. $D = \frac{1750}{1000} = 1.75°$

   d. $D = \frac{1750}{3500} = 0.5°$

2. Find out the Radius of the curve having following Degree
   a. 0.5° b. 1.5° c. 3° d. 2.9°

   Solution

   Formula Used : $R = \frac{1750}{D}$

   a. $R = \frac{1750}{0.5} = 3500\ mtrs$

   b. $R = \frac{1750}{1.5} = 1166.66\ mtrs$

c. $R = \frac{1750}{3} = 553.33\ mtrs$

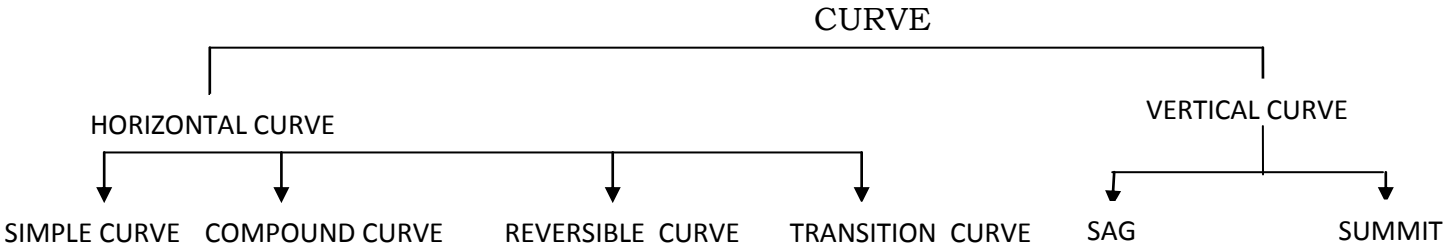
d. $R = \frac{1750}{2.9}$= 603.448 mtrs

Necessity of curve :

Although laying and maintenance both are easy in straight line but due to the following reasons . it is essential to lay Curved Track.

1. To avoid Rivers, Mountains and other obstructions like this
2. To avoid construction of major bridges, tunnels and deep cuttings
3. To Connect the important cities with main line.

Classification of curve



Horizontal Curve:

The Curves laid on horizontal Plane is Known as Horizontal Curve

Simple Circular curve :

Normally this curve is simple curve which connects two straight alignment(Line/Track). Since it has uniform radius, Degree of curvature throughout its length. It is considered as standard and it is the most used type of curve used in Indian railways.

Compound Curve

When two or more circular curve whose radius are different laid in continuation to other in such a manner that there centre's are at the same direction (side) only forms the compound centre's.

In the compound curve there may be transition in between the curves may not be.

Reverse Curve :

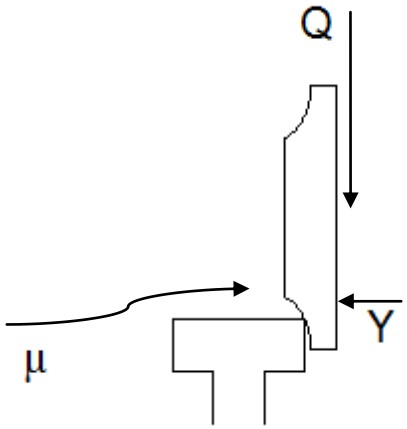
. When two curves of same (or) different radius next to each other in such a way that their flexures lay in opposite directions, then this is known as reverse curve

In this case the centre's of two curves will always lay in opposite direction on account of the shape it is also known as 'S' curve. There may be (or) may not be transition in between the two curves.

Transition Curve :

It is a curve having varying radius throughout its length. In Indian Railways this curve is laid at both ends of simple curve for gaining / loosing the degree of curve from/to straight. Its shape is cubic parabola and it is also known as easement of curve.

MOTION OF WHEEL ON CURVE:



Q=Instataneous load (or) stabilizin Force

Y= Flange Force (or) Derailment Force

μ= Frictional Force

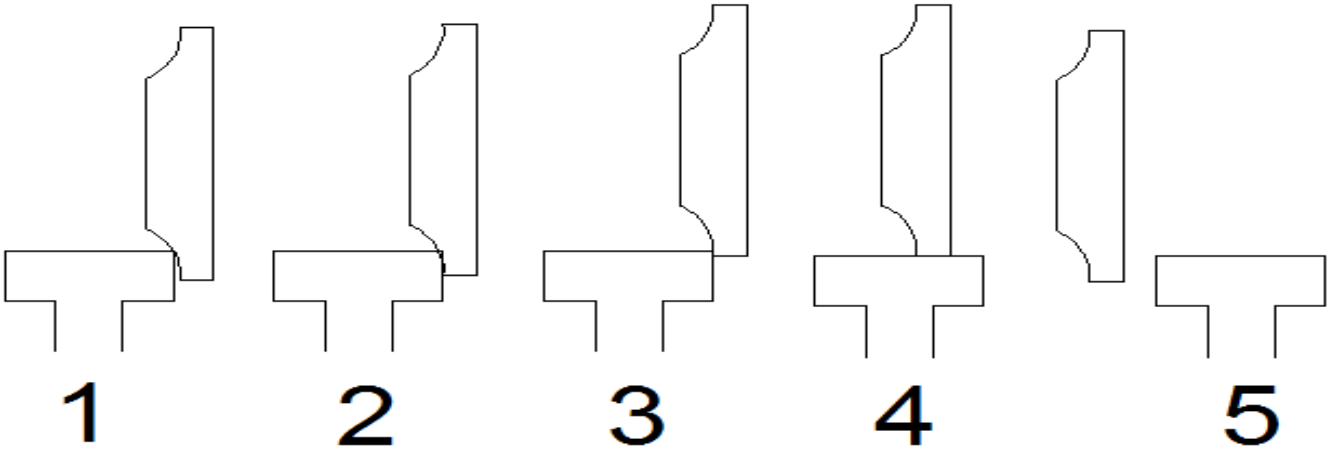
NADAL'S EQUATION:

Q> Y+ μ ✓ (Safe Moment)

Q< Y+ μ× (Chances of Derailment)

Factors Effecting μ (Frictional Force)

The value of μ should be as less as possible. Increased Value of μ increases the tendency of Derailment



3. Sandy Particles on Rail

Super Elevation On Curves :

Necessity for providing cant:

When a vehicle moves on a curved track it as a tendency to take a straight path while doing this the flange of leading outer wheel exerts pressure on outer rail. In reverse of it outer rails also exerts pressure on wheel flange, which helps the wheel to move on curve path. Hence the flange force is essential for motion of wheel on curve.

As soon as vehicle enters in a curve. It is subjected to centrifugal force. Which direction is always away from centre of curve. Due to the centrifugal force, flange pressure increases on outer rail much more. This additional pressure due to centrifugal force should be counter acted (balanced) by another force. This force is generated by changing direction of self weight of vehicle . which is achieved by raising the outer rail to such an extent so that result of centrifugal force and vehicle weight should pass at right angle through centre of track means both rails will bear equal load on it.

Cant or superelevation is the amount by which one rail is raised above the other rail. It is positive when the outer rail on a curved track is raised above inner rail and is negative when the inner rail on a curved track is raised above the outer rail.

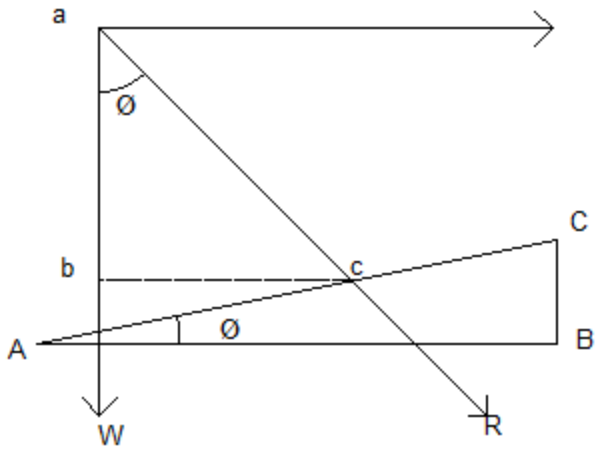
Purpose of providing Super –Elevation :

1. To counter balance the centrifugal force
2. For proper distribution of load on both rail is (Inner & Outer)
3. For comfort of passengers
4. To reduce the chances of wheel mounting
5. To reduce wear and tear of the rail as well as the rolling stock

Maximum Value of SE on BG Track

1. **For Normal speed track (Upto 100 KMPH)**
   - **a.** Normal : **140 mm**
   - b. With the permission of CTE : **165 mm**
2. **For High speed track (above 100 KMPH)**
   - a. Normal : **165 mm (A,B & C route)**
   - b. With the permission of CTE : **185 mm**

Derivation of Formula for Super Elevation



$$CF = \frac{mv^2}{R}$$

Given :

AB=AC= Track Gauge

BC = Super Elevation

W= Weight of Vehicle

R = Resultant of Weight

In $\triangle$ ABC $\rightarrow$ $Tan\emptyset = \frac{BC}{AB} \rightarrow$ eq 1

In $\triangle$ abc → $\quad$ $\text{Tan}\emptyset = \frac{bc}{ab}$ → $\quad$ eq 2

Equating 1 & 2

$\frac{BC}{AB} = \frac{bc}{ab}$

$BC = \frac{bc}{ab} \times AB$

$SE = \frac{G \times mv^2}{mg \times R} = \frac{G\,v^2}{g\,R}$

$SE = \frac{G\,v^2}{g\,R}$

Where :
SE(Super Elevation or Cant) is in mm
G(Gauge) is in mm
V(Velocity)in Km/Hr
R(Radius) is in metres

For MKS System Putting Value

Track gauge = $\frac{G}{1000}$ meter

V (Speed in Km/Hr) = $\frac{1000}{60x60}$ V m/sec = $\frac{5}{18}$ V m/sec

Now :

$SE = \frac{G\,v^2}{g\,R} = \frac{G}{1000} \times \frac{5}{18} V \times \frac{5}{18} V \times \frac{1}{9.81} \times \frac{1}{R} \times 1000$

$SE = \frac{G \times 25 \times v^2}{18 \times 18 \times 9.81 \times R} = \frac{25G\,v^2}{3175\,R}$ mm

$SE = \frac{G\,v^2}{127\,R}$ mm

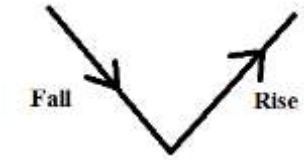
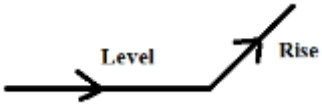
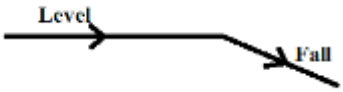
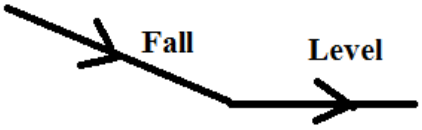
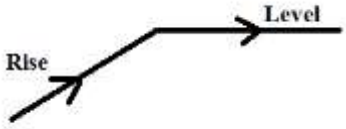
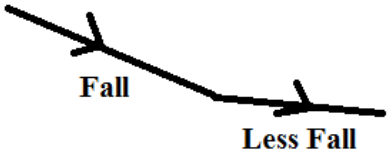
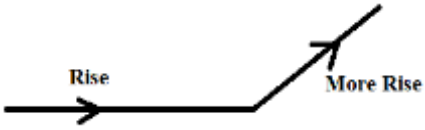
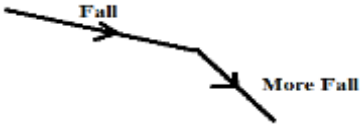
Vertical Curve

The curve which are provided in vertical plane and used to ease on to the change of gradients are called Vertical Curve

Necessity :

When two gradients meet each other an angle is formed at the junction forming the 'Sag' (or) 'Summits'. In case of Sags there is a danger for derailment due to motion of vehicles and in case of Summits, there is danger for train paring. Therefore to eliminate the sags and summits vertical curves are provided.

Causes of Sags and Summit:

S.No	Sag	Summit
1		
2		
3		
4		
5		

Note :

1. Since vertical curves are very short, hence for all practical purpose it is treated as simple curve.
2. Vertical curve shall be provided only at the functions of two grade is either equal to or more than 4mm/m or 0.4%.

Minimum Radius of Vertical Curve:

As per IRPWM and LWR manual the minimum value of radius of vertical curve is as below

BG : A route = 4000 mtrs
B route = 3000 mtrs
C route = 2500 mtrs

MG : All routes = 2500 mtrs

Equilibrium Speed and Equilibrium Super Elevation

Equilibrium speed is the speed at which the centrifugal force developed during the movement of the vehicle on a curved track is exactly balanced by the cant provided.

For a particular curve on a particular speed super Elevation Provided by Formula $\frac{G v^2}{127 R}$ is known as Equilibrium Super Elevation and the particular speed is known as Equilibrium Speed.

Provision of Equilibrium Super Elevation in track is not possible due to following reason's

1. Provision and maintenance of much cant in track is not comfortable.
2. It's effect on slow moving track will be as below
    a. Chance of derailment of inner wheel will increase
    b. Reaction on inner rail is increased
    c. In storm chances of overturning of wagon will be increased.

Note:

The equilibrium state means effect C.F. on curve is totally counter balanced and resultant of C.F and vehicle weight passing perpendicularly to rail level plane in centre of track.

Cant Deficiency:

When a vehicle run on curved track by more than the equilibrium speed cant deficiency is observed.

The difference between the super elevation required for maximum permissible speed on the curve and the actual super elevation provided on the curve is known as cant deficiency

$$\textbf{Cant deficiency} = C_{mps} - C_{Actual}$$

Where C_{mps} is Cant on Maximum Permissible Speed

C_{Actual} is Actual Cant Provided.

Ma**ximum Value of Cant Deficiency on BG Track:**

For Speed upto 100 Kmph ➔ **75mm**

For high Speed more than 100 Kmph ➔ **100 mm**

Adverse Effect of Cant Deficiency:

1. Outer rail and wheel flange wear more
2. Lateral disturbance of track due to unbalanced centrifugal force
3. Discomfort to the passenger
4. Chances of Derailment of vehicle/wagon is increased

Cant Excess

Cant excess occurs when a vehicle run on a curve at a speed lower than the equilibrium speed cant Excess is observed.

It is the difference between the actual cant and the theoretical cant required for such a lower speed.

Maximum value of Cant Excess ➔ **75mm**

Adverse effect of Cant Excess:

1. Wear and tear of inner rail and inner wheel flange is increased.
2. Chances of derailment of vehicle is increased due to 'Off-loading' of outer wheel
3. Discomfort to passengers
4. Chances of overturning of vehicle in blown air is increased
5. Chances of displacement of consignment in wagon

Maximum permissible speed (MPS) of the curve-

The highest speed which may be permitted on a curve is known as Maximum Permissible Speed of the curve.

The speed is permitted by taking into consideration of the following factors

i. The radius of the curvature
ii. Actual cant Provided
iii. Cant deficiency/Cant excess
iv. Transition Length of the Curve

When the maximum permissible speed(MPS) on a curve is less than the maximum sectional speed(MSS) of the section of a line, permanent speed restriction becomes necessary. So a permanent speed restriction is imposed(Provided) on that particular curve

Maximum Sanctioned / permissible Speed of Section (MSS)

The highest speed permitted by Commissioner of Railway Safety (C.R.S) for a particular section is known as Maximum Sanctioned / permissible Speed of Section (MSS)

This depends upon the track structure and locomotives used for that section. Driver should not cross this speed in any case.

Booked Speed:

It is the Speed on which a particular train is allowed or booked to run in a particular section. Normally this speed is lesser by 10-12% from the MSS.

Cant gradient and cant deficiency gradient

This indicates amount by which cant or deficiency of cant is increased or reduced in a given length of transition

e.g., 1 in 1000 means that cant or deficiency of cant of 1 mm. is gained or lost in every 1000mm/1m. of transition length.

Rate of change of cant or rate of change of cant deficiency

This is the rate at which cant or cant deficiency is increased or Decreased per second, at the maximum permissible speed of the vehicle passing over the transition curve,

e.g., 35 mm. per second means that a vehicle when traveling at a maximum speed permitted will experience a change in cant or deficiency of cant of 35mm. in each second of travel over the transition Curve.

Initial Days it was **55mm/sec** in BG Track

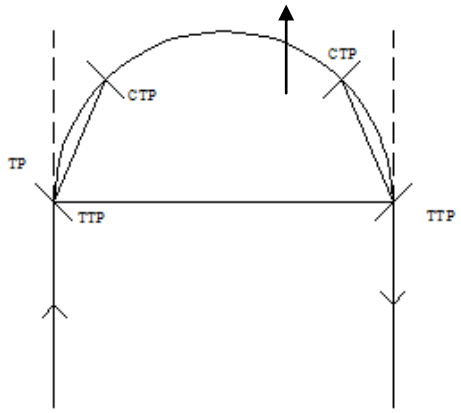
Nowadays it is **35mm/sec** in BG Track

Speed on curve'D' and 'E' Routes (M.S.S is 100 kmph)

Assumption of Equilibrium Speed

¾ of the Maximum Speed

TRANSITION CURVE



TTP – Tangential Tangent Point

CTP – Curve Tangent Point

$C.F = \frac{mv^2}{R}$

$\frac{mv^2}{R}$ = Radial acceleration

Necessity of Transition Curve:

When a vehicle passes with an uniform speed on a curve it is subjected with radial acceleration resulting

$\frac{V^2}{R}$ Where V= uniform speed, R = Radius of curve

When a radial acceleration acts uniformly or rate of change of radial acceleration is less than 0.35 meter/sec. there is no discomfort to the passengers

When a vehicle runs on a straight track there is no radial acceleration/centrifugal force reacts on it. As soon as the vehicle enters in a curved track from straight track it is subjected to sudden radial acceleration resulting (at longest) which not only causes discomfort to the passengers but also infringes the safety on slow speed. This jerk will be less and on high speed this jerk will be more. Hence on high speed routes transition curve is essentially provided not only for comfort but also to assure safe running of vehicle. In order to provide smooth entry and exit of train in the curve. The transition curve is provided on either side of the circular curve.

The radial acceleration is build up (or) easement curve in which degree of curve is gained (or) lost gradually while entering from straight line (or) vise versa .

The centrifugal force generated due to above radial acceleration is counter balanced by (raising of outer rail of curve) providing super elevation on curve on tangent point of curve. Sudden raising of rail is not possible. Hence gradual gain of super Elevation and Cant deficiency is carried out in transition length of curve.

Objects of introducing transition curve

1. By providing transition curve we achieve degree of circular curve gradually from straight to curve (infinite radius to curve radius) which helps the vehicle to negotiate curve smoothly.
2. To provide gradual increase of the super elevation from zero of straight track to desired super elevation of the curve

3. Easy and smooth entry and exit of the vehicle from straight to curve and vise-versa.
4. To reduce/ avoid the chance of derailment.

Requirement of transition curve;

1. It should be tangential to the straight (i.e) it should start from straight with zero curvature (infinite radius) at TTP.
2. It should join the circular curve tangentially (i.e) at the end it should have the same curvature (radius) as that at Circular curve at (CTP).
3. The curvature should increase at the same rate at the super elevation increases
4. The length of the transition curve should be adequate to attain the full super elevation which increases gradually at the specified rate.

Shape of transition curve:

The shape of the transition curve in Indian Railway is normally 'Cubic Parabola'.The equation is

$$Y = \frac{X^2}{6\,RL}$$

Where

R= Radius of Curve,

Y = offset ,

X= Distance from TTP ,

L= Length of Transition Curve

In this type (shape) of curve both the curvature and cant increases at the linear rate

Length of Transition Curve for speed up to 100 Kmph

a) $\frac{E \times Vm}{134}$

b) $\frac{D \times Vm}{134}$

c) 0.72 x E

Where

E = Actual Cant

D = Actual Cant Deficiency

V_m = Average Speed

Curve on High Speed Route (On BG Curve)

Sn	Parameters	For normal speed upto 100 Kmph	For normal speed upto 100 Kmph
1	Maximum Cant	140 mm	165 mm
		165 mm (If CE passes)	185 mm (If CE passes)
2	Equilibrium Speed	¾ of M.S.S	To be decided by Chief Engineer for each Section
		Safe Speed whichever is less	Maximum of 100 Kmph upto 2° curve
3	Cant Deficiency	75 mm	100 mm for nominated routes (A & B) and Rolling Stock
4	Maximum Cant Excess	75 mm	75 mm
5	Safe Speed For Maximum Perspect of Curve 1. For Transition Curve 2. For non-Transition Curve	1. V =$4.4\sqrt{R-70}$ 2. 4 /5 of M.S.S	Speed Potential V=$\sqrt{\frac{(Ca-Cd)x\,R}{13.76}}$ Derived by $\frac{G\,v^2}{127\,R}$ (or) V = $0.27\sqrt{(Ca-Cd)x\,R}$
6	Rate of change of Cant Deficiency	38 mm/sec	1. Preferable for it should be 38 mm/sec 2. In extreme cases in an case it should not exceed 55mm/sec

7	Cant Gradient	1. 1 in 720 desirable 2. 1 in 360 Maximum (Not more sharper in any case)	Cant gradient so choose that the rate of change of cant & cant deficiency at maximum permitted speed does not exceed 55mm/sec under any circumstance. For design of future layout of curve or cant gradient if sharp be assumed 1 in 1200
8	Track Gauge	1676 mm	Dynamic gauge will be considered for speed calculation
9	Maximum speed for which 6 & 7	Upto 100 Kmph	Upto 160 Kmph

Length of Transition Curve on high speed route (minimum Length)

1.**Minimum Length of Transition**

a) $\frac{C_d \times V_m}{198}$

b) $\frac{C_a \times V_m}{198}$

Where

C_a = Actual Cant

C_d = Actual Cant Deficiency

V_m = Average Speed

Which one is greater and in next multiple of 10

Desirable Transition Length

Greater one and in next multiple of 10 from following

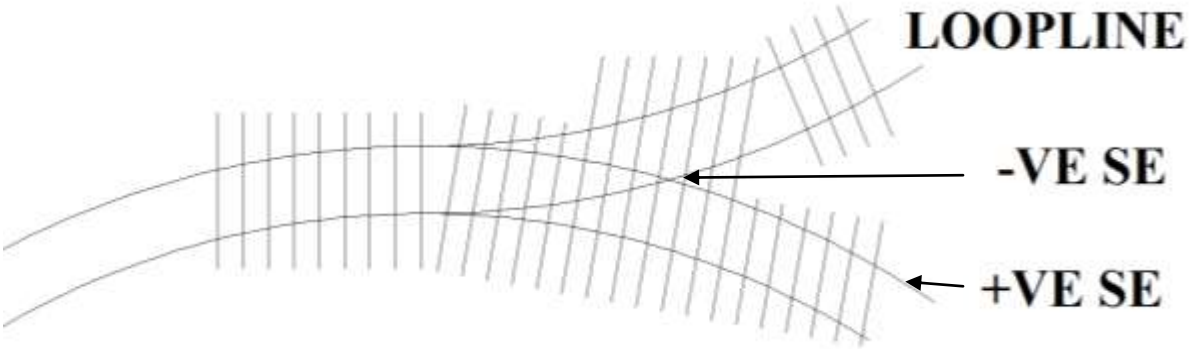
a) $\frac{C_a \times V_m}{137}$

b) $\frac{C_d \times V_m}{137}$

c) 1.2 x Ca

Negative Superelevation :

On curve the amount by which the inner rail is raised in comparison to outer rail is known as negative super elevation.



-ve super elevation is provided at the location where turnout takes off from curve main line in contrary flexure.

Note:

1. In case of negative super elevation speed restriction must be provided on loop line as well as known also in m/l as resituation.
2. Max value of –Ve super elevation is 50mm

EXTRA CLEARANCE ON THE CURVE:

In schedule of dimensions(SOD) distance of various structure is given from centre of straight track . But when a vehicle moves on curved track. There dimensions consistence's are not sufficient in selection with maximum moving dimensions of vehicle due to lean, learch sway , over throw and End throw etc resulting infringement occurs with open doors of vehicle. To avoid above infringement extra clearance are provided on curved track.

Effect of super Elevation (Lean)

On account of super elevation provided on curve vehicle lean towards inside of the curve, when required extra clearance mathematical value

Lean = $\frac{h-e}{G}$

Where

h- height of the vehicle

e- Super elevation

G – Track Gauge

Effect of Un Balanced centrifugal force (sway)

On account of unbalanced centrifugal force caused due to cant deficiency vehicle has a tendency to additional sway which required extra clearance towards inside of curve

Check Rail on Curve :

Check rail are basically provided on sharp curve with inner rails on gauge track side due to following reasons

1. Due to un even loading of vehicle due to worn out wheels due to long wheel base and due to insufficient S.E [Cant deficiency] there are always chances of mounting of outer wheel on outer rail resulting in De-Railment. Check rails prevent the wheel mounting on outer rail as well as decreases the chances of derailment.
2. Due to flange force and un-countered centrifugal forces outer rail gets wear rapidly on sharp curve .

Check rail prevents the wear of outer rail, but it wears rapidly itself which is cost wise not valuable because it is used with release rail

3. It increases the lateral stability of track on sharp curve

Dis-Advantages of check rail

1. Additional track Maintenance cost
2. Additional resistance provided to moving wheels resulting increase of haulage cost
3. Additional wear in inner rail.

Degree of limitations

BG → 8° and above check rail should be provided

Check rail clearance

1. Minimum rail clearance = 44 mm
2. Maximum rail clearance = 48 mm

Note : if gauge slackness is provided on curve check rail clearance (CRC) will also increase by ½ of its amount.

Necessity of gauge slack on curve

On sharp curve gauge are kept slack free movement of the rigid wheel base bogie and reduce the excessive wheel flange (or) on outer rail on B.G track the gauges are kept slack As under

1. Upto 4° = Exact gauge
2. More than 4° = + 6mm

Lubrication on Gauge face of outer rail of curve:

Greasing will be done on outer rail gauge face at curve due to reduce the frictional loss of wheel more than plate only.

On curve to reduce the outer rail wear it is the best method to lubricate the gauge face / inner face of outer rail. By lubricating the outer rail gauge face we achieve (gain) the following advantages

⇒ Than 50% wear and tear of the outer rail and outer wheel are reduced
⇒ Fuel economy increases
⇒ Condition and parameters of the curve is maintained
⇒ By reducing the frictional losses we can increase the speed on sharp curve
⇒ Chances of derailment reduced
⇒ Haulage cost are reduced

JOINTS AND WELDING OF RAIL

TYPES OF THE JOINTS

1. Ordinary fish plated joints [Normal joint]
2. Joggle fish plated jointd [on ward fracture joints]
3. Insulated joints [in track circuited areas]
4. Glued Joint [In track circuited areas]
5. Switch Expansion Joint[SEJ] at the end of LWR/SWR.

Fish plated joint

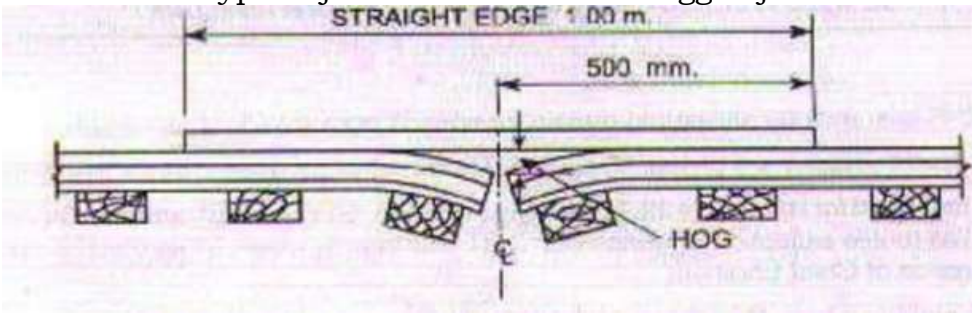
Joggled Fish plate

Glued Joint

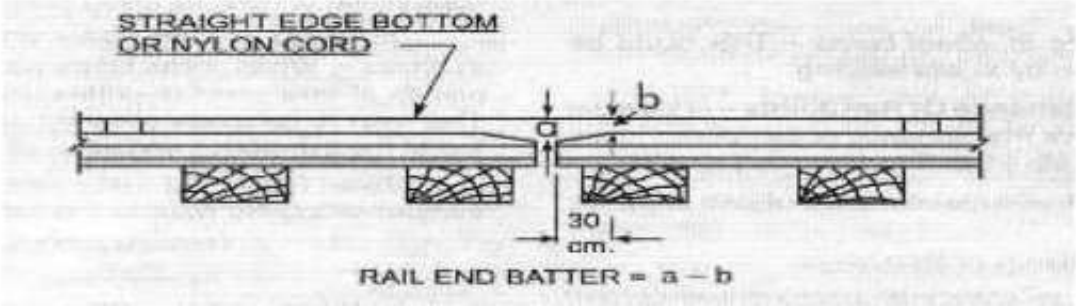
SEJ

Defects of joints

1. **Hogged joint** :- in this defect , rail at joint bends permanently in downwards and a rail at end is permanently subjected with vertical kinks. These type of joints are known as hogged joints.



2. **Battered joint** : It is caused by the impact of wheel at the end of rail. Occurs where the joint gaps are excessive. Rail end batter is measured as difference in heights of rails at its end and at a point 30 cm away from rail end.



3. **High joint** : During the work of maintenance sometimes joints are packed more than required, resulting it becomes high than running on such joints becomes very bad because these joints give some vehicle lift while passing at the wheel
4. **Low joint** : in sufficient packing of joints gives down leveling of joints resulting bad running (or) riding of train. After sometimes these joints are converted in hogged and battered joints . if not attended with in short time period.
5. **Blowing joints** : when within dust blows from joints under the moving train the joints . In such joints there are always white dust in surroundings of joints . These joints are generated due to
    1. Low maintenance level of the track joint
    2. Packing with dirty ballast
    3. Bad quality of soil

    Maintenance of such type of joints are very necessary

6. **Pumping joints** : In raining season the blowing joint converts into pumping joints . in rainy season the water fills in the underived water packets[which are generated due to blowing of joints/ weak soils] and mud comes out while passing of trains from on it, maintenance of such joints are very difficult due to weak formation ballast penetration under the formation and packing does not retains under these sleepers.

Necessity for welding of rail joints

In the modern age of track technology with concept of high speed routes, the welding of joints becomes necessary due to following reasons:

1. Due to impact of moving load at joint ballast under the joint sleepers gets loosen particularly on loose / defective fish plated joint(F/P) regularly. Hence maintenance of joints need more attention, money and labour.
2. Due to different joints defects like hogging, battering etc the service life of track components gets reduced

3. A lot of noise pollution is created on fish plated track particularly on loose/ defective joints. Resulting discomfort to passengers.
4. Due to loose / defective joints lets chances of derailment are much more at fish plate
5. Chances of sabotage at fishplate joints are more and easy because it can be done by easily removal of fish plate from track
6. Service life of components of rolling stock is also reduced on fish plated track due to different types of wear and impact
7. Resistance developed by fish plate joints against rolling of rolling stocks increases fuel consumptions is more
8. 50 % to 80% extra labour / time/money is required to maintain the joint in fish plated track
9. Due to above various reasons. It is difficult to run the train on high speed on fish plated track
10. Fish plated track is not suitable for modern methods of maintenance of track.

Advantages of welding of rail joints

1. More than 50% maintenance cost reduced in welded track compared to fish plated track
2. By eliminating rail joints an uniform smooth floating track is achieved which results smooth running of train.
3. Easy to maintain track parameters with uniform ballast cushion which gives the high speed on track
4. Due to achieving uniform and good parameters on welded track , chances of derailment is reduced
5. Life of track components as well as rolling stock increases
6. Safe and anti-sabotage type of track achieves resulting curtailing in extra expenditure on security
7. Noise pollution reduces resulting increase in comfort level of the passengers
8. Low friction pathway achieved resulting cost reduced.
9. Track capacity increases
10. Fuel efficiency increases
11. Suitable for modern method of packing(Track Maintenance)

Types of Welding

The various types of rail welding techniques are as follows

1. Oxy- acetylene welding
2. Electric arc welding
3. Flash butt Welding
4. Alumino-thermit welding

Oxy Acetylene or Gas Welding

In this type of welding necessarily heat is produced by a combination of oxygen and acetylene gas. The rail ends to be welded are brought together and heat is applied through a burner. Temperature upto 1200°C to 1400°C is achieved, so that the metal of the rail ends gets melted and fusion takes place, welding the rail ends together.

Electric Arc welding

In this method the heat is created by the passage of electric current across a gap between two conductors. About 3500°C temperature is achieved causing the two rail ends weld together

Flash Butt Welding

In this method heat is generated by electric resistance. The two rail ends are fixed in movable and fixed jaws and brought together so that they almost touch each other. The electric energy is switched on thereby allowing an electric current of about 5 volt and 35000 ampere to pass between faces of two rails, lot of flashing takes place at the interface and considerable heat is generated rising the temperature from 1000°C - 1500°C(fusion limit of steel). At this time the rail ends are pressed together with upset pressure of about 5 to 7 Kg/mm^2 and welding of the rails take place.

Note: Quality of weld joint is very high since there is no foreign material is used as filler

Welding time: 150-200 sec (5-6 minutes for complete process)

Output : 60-80 joits in 8 hr shift

Flash butt welding is carried out in Depots.

Alumino – thermit welding:

This is the only form of site welding. Its principle is that when a mixture of finely divided aluminium and iron oxide called thermit mixture is ignited a chemical reaction takes place with evaluation of heat, producing iron and Aluminium oxide. The iron released from the reaction is in molten condition (24500c), which is poured in the gap between the two rails, welding the rail ends together. The equation which follows is:

$$2Al + Fe_2O_3 \text{ .....} > Al_2O_3 + 2Fe + heat$$

Brief Procedure of Flash Butt Welding:

1. **Pre-Straightening of rails**:

   The rails are straightened before welding to get a good alignment of the welded rail. Pre –Straightening can be done either manually using ordinary or hydraulic jim crow or by Pre-Straightening machines with the help of hydraulic rams

   Pairing of rails is also done before pre-straightening of rails for better results.

2. **End Cleaning of Rails**

   The end cleaning of rails is then done for a length of 150mm to 225mm by electric or pneumatic grinders or shot blasting/sand blasting on top, bottom and interfaces in order to ensure better conduction of electric current at the rail ends. This could be done by grinding, brushing or shot blasting.

3. **Adjustment of rail ends:**
   The rail ends are then brought together in the flash butt welding m/c and the longitudinal and vertical alignment of the rail is corrected by suitable adjustment of the machine
4. **Welding**

During welding using flash butt welding machine, the following processes are involved.

a. Initial Burn Off

First of all, irregularities of the rail interfaces are burnt off to make the end surfaces smooth and parallel so that when pre-heating takes place, the weld current can flow over the complete weld interfaces.

b. Pre-Heating

In this process preheating, the heat is generated by the **electrical resistance** offered at the ends of both rails. The rails are clamped and tightened in the jaws in which one jaw is **fixed** and the other is **movable** so that gap adjustment can be done in between the rails ends. The rail ends are brought into contact to allow a low voltage of **5 Volts** and high current of **35000 Amperes** flow which preheats the rail ends upto red hot stage. The movable jaw is alternatively moved forward and backward producing a series of electric contact. Lower voltages are preferred to minimize crater damage on the rail ends. This pre-heating cycle executed in a fully controlled automatic mode once the parameters are selected.

c. Flashing

This stage involves the movement of rail in continuous manner initially at uniform speed and last few seconds at accelerated rate. Speed is such that rail ends are burned out without short circuiting. Due to this process a **flash is generated** between the ends of rails till the temperatures reaches to **1000 to 1500^{o}C**.

d. Forging (Up setting) &

Immediately after the flashing, the rail ends are butted together to a stage of fusion under a heavy butting pressure for 10 seconds (approximately). The recommended butting pressure for different types of rails is indicated below

Type of Rail	**Butting Pressure / Cross Sectional Area**
72 UTS rails	5kg/mm^2
90 UTS rails & Head Hardened rails	6 kg/ mm^2
110 UTS rails	7 kg/mm^2

e. Main Welding

At the last when the ends are fused and the temperature is raised upto 1500^{o}C the rails ends are finally butted at 37 tonnes of flashing stroke pressure and thus get welded.

Note:

1. In this process, due to butting and flashing stroke,rails are reduced by 20 mm(approx.) in length.
2. Approximately 150 to 200 seconds are taken in welding process only.

5. Stripping or Hot Chipping

As soon as the rails are welded the stripping is done automatically or by pneumatic chisel for removing extra materials from the joints and surfaces.

6. Spray Cooling

After the heat metal is chipped off the rails are cooled by spray cooling by a sprayer at a distance of 60 to 70 meters from the welding machines.

7. Profiling

The rails are finally ground to correct profile preferably by using profile grinding machine or trolley grinder, Hand grinders are used only in case of emergency.

8. Post Straightening

The rails are straightened by means of post straightened machines of 200 tons capacity which removes horizontal and vertical kinks , if any so as to give perfect alignment of both directions.

9. Ultrasonic Inspection

The rails are well as welds are given an ultrasonic examination to ensure that there are no flaws in the rails. This is particularly for second hand rail

10. Examination and Inspection

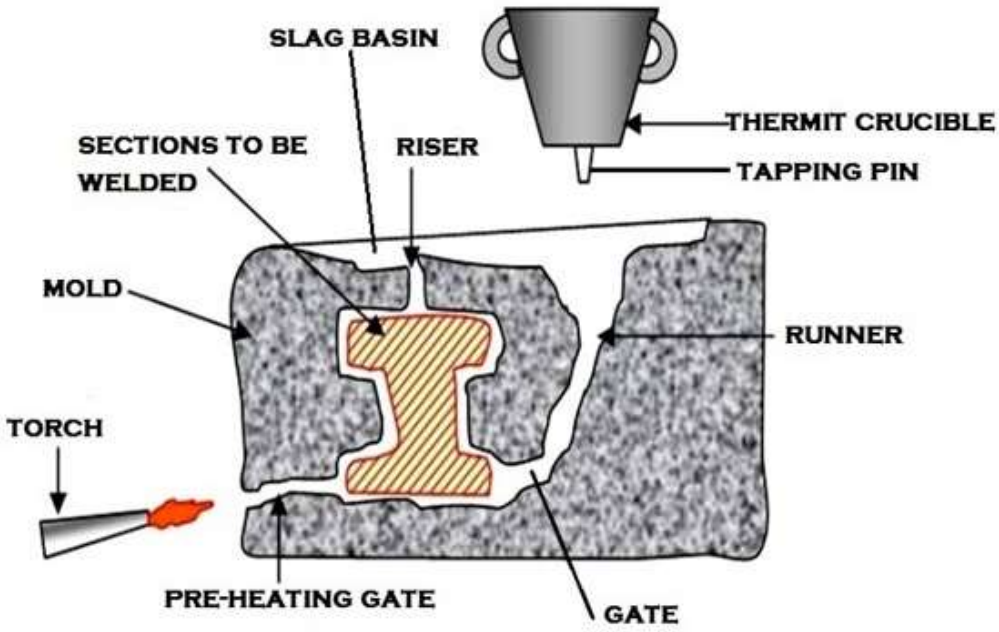
The rail ends are finally examined and inspected with regard to specified tolerances so as to have finally a good welded surface, It should be ensured that direction of ingot as marked on the rail should not be changed while welding

Tolerance for Flash Butt Welding Joint

S.No	Item	Tolerance for Welds With	
		New Rails	Old Rails
1	Vertical misalignment	+0.3 mm, 0 mm at the centre of a 1 m straight edge.	±0.5 mm at the centre a 1 m straight edge.
2	Lateral misalignment	± 0.3 mm at the centre of a 1 m straight edge.	±0.5 mm at the centre aim straight edge.
3	Head finishing (on sides)	±0. 25 mm on gauge side at the centre of 10 cm straight edge	±0.3 mm on the gauge side at the centre of a 10 cm straight edge.
4	Head finishing (on top table surface)	+ 0.2 mm ,0 mm at the centre of 10 cm 0 mm straight edge.	±0.2 mm at the centre of a 10 cm straight edge.
5	Web zone (under side of head, web, top of base and both fillets on each side)	+ 3.0 mm , 0.0 mm of parent contour	+ 3.0 mm , 0.0 mm of parent contour

ALUMINO – THERMIT WELDING:

This is a form of site welding. Its principle is that when a mixture of finely divided Aluminium and Iron oxide called thermit mixture (thermit portion) is ignited, a chemical reaction takes place with evolution of heat, producing Iron and Aluminium oxide. The iron released from the reaction is in molten condition (2450^0C), which is poured in the gap between the two rails, welding the rail ends together.



The equation which follows is:

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe + heat$$

(54 gms) + (160 gms) ➔ (102 gms) + (112 gms)

PROCESS OF AT WELDING

In Indian railways mostly Short Preheat Welding (SKV) is followed. The following procedure is of SKV welding.

1. **Preliminary works**
   - **a.** A minimum traffic block of 70 to 75 minutes duration depending upon the type of preheating technique adopted, should be obtained for complete operation of welding of first joint and to ensure good quality of AT weld.
   - **b.** Loosening of rail fastenings.
     - **i.** Fastenings of 5 sleepers on either side of the welding spot.
     - **ii.** 250 mm clear working space is required to accommodate moulds, clamps etc.

Note: when welding is done at cess wooden blocks shall be used to level the full rail length.

- **c.** Lateral and vertical alignment shall be corrected.
  - **i.** Lateral alignment tolerance : ± 0.5 mm (measured with 1 meter straight edge)
  - **ii.** Vertical alignment: joint shall be kept higher to compensate against sagging caused by shrinkage on cooling.

Achieved by using wedges.

72 UTS	1.5 to 2 mm	Measured by 1 m Straight edge
90 UTS	1 to 1.2 mm	

- **d.** Sleepers should be moved to make 250 mm gap for provision of wooden block under joint after welding
- **e.** The gap between the rail end shall be maintained.

  Gap= 25 ± 1 mm

  If required, rail tensors can be used to maintain gap.
- **f.** Preparation of rail ends to be welded

  Rail end faces and adjacent sides upto 50 mm from end are thoroughly cleaned by Kerosine oil and wire brushed to remove dirt and grease.

2. **Operation during welding**
   - **a.** Fixing of pre-fabricated mould.

     Prefabricated mould should be centrally fixed on joint with the help of clamp. Precaution should be taken that chisel mark (➔) should be matched for correction of center.
   - **b.** After fixation of pre-fabricated mould gaps are packed/closed with the help of looting sand. Remove the unwanted sand entering the mold by spatula.

Note: ensure service life of looting sand is not expired (expiry period: 4 months from date of mfg.)

c. Preheating of rails

After fixing mold rails are uniformally preheated throughout the section with oxy-petrol or oxy-LPG burner.

Temperature to be achieved = 600 ± 20 °C

Time of preheating and pressure are maintained as below

Type of burner	Time of preheating (minutes)	Pressure (kg/cm^2)
Oxy-Petrol burner	10-12	7 ± 0.7 (Oxygen)
Oxy-LPG process	2-3	LPG: 2-2.5 (open first) Oxygen: 7-7.5 (open second)

d. Fixing of crucible on Rail head

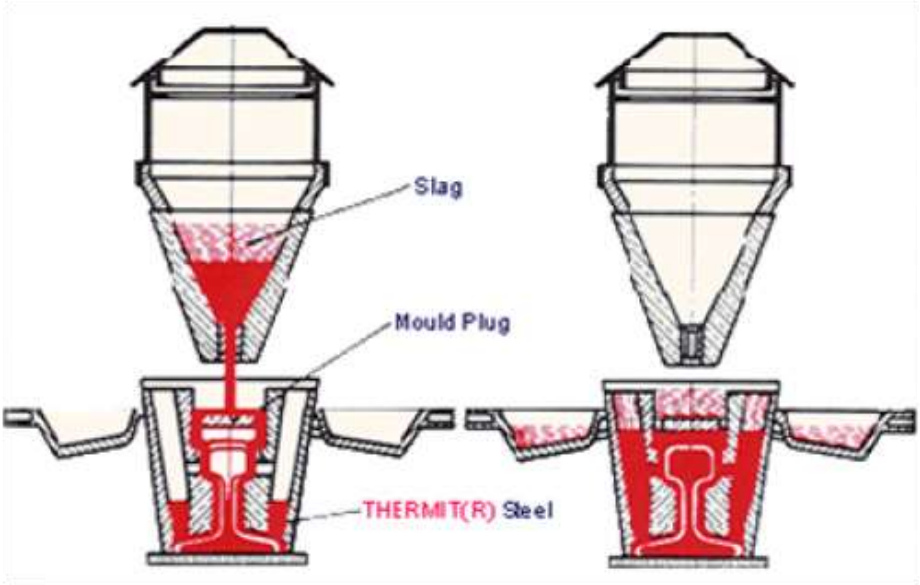
i. Special type of crucible with swinging rotary stand is fixed on rail head.

ii. The gap between crucible and mould should be 50 mm.

iii. Close the crucible bottom with the help of a thimble
Thimble is a closing pin covered on top with asbestos and slack powder

iv. After that thermit portion is filled in the crucible.
Weight of thermit portion : 10.5 kg ordinary (52 kg rail)
: 13 kg modified.
Excess amount in modified case can preheat the rail more effectively.

e. Ignition of portion and pouring of metal in mould.



i. After completion of preheating portio is ignited with the help of ignition lighter.
Ignition lighter : Barium per oxide + Aluminium
Angle of ignition : 45° (in order to have more exposed area over portion.
Reaction time = 20-25 sec
Slag separation time = 5 sec
Total time = 30 sec
Temperature of crucible = 2450 °C

Note : Due to slag comes to top and molten Iron (Fe) being heavy goes to bottom of cruisible.

Chemical Reaction

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe + heat$$

(54 gms) + (160 gms) ➔ (102 gms) + (112 gms) + 132 Kcal.

ii. After removing the heat torch, the crucible is swung towards the top center of the mould with gap around 50 mm. closing pin is then pushed up. Molten metal gets poured into prefabricated mould. Crucible is then swung around again to flow out the slag

Note : improper chemical reaction of portion due to presence of moisture is called boiling of portion. Such kind of mixture should not be poured in to mould, it should be thrown outside.

f. Demolding time.
After completing the pouring of metal in P F mould, the mould box should be removed from the joint by allowing a setting time.
Setting time = 3.5 – 4 minues

g. Chipping and grinding of rail joint
Excess material should be chipped off with the help of hot chisel. First guage face is chipped off, followed by top face and finally both sides are chipped off. On top face 1.5 mm excess metal is left for grinding. Other residues are removed by wire brush.

3. Post welding operation

a. Cooling of rail ends : controlled cooling for 3-4 minutes

b. Removal of equipment : crucible, slag pan, mounting, mould shoes etc. are removed in sequence.

c. Removal of excess metal by weld trimmer: hydraulic weld trimmer is used for the purpose.

d. Finishing of weld joint : grinding using portable profile grinders in same day of welding or in next day with all tolerances.

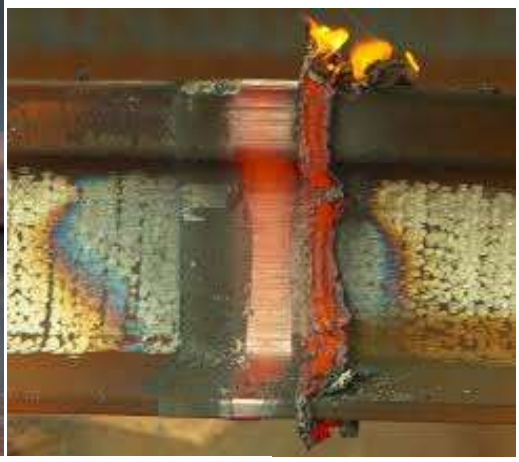
e. Joint shall be joggled with 4 bolts and supported by wooden blocks.

f. Painting of rail joints : 10- 10 cm in both sides.

g. First train passed after 30 minutes.

h. Local distressing shall be done for 125 m on both sides.

i. USFD testing with in one month.
In USFD testing the welded joint is ultrasonically tested essentially to detect any flaw or blow hole in it. If there is any flaw, the joint is defective and is removed by cutting by automatic machine and rewelded by above process.



Tolerance for Alumino thermit Welded Joint

S.No	Item	Tolerance for Welds With
1	Vertical misalignment	± 1.00 mm at the end of a 1 m straight edge.
2	Lateral misalignment	± 0.5 mm at the end of a 1 m straight edge.
3	Head finishing (on sides)	±0.3 mm on at the centre of 10 mm straight edge.
4	Head finishing (on top table surface)	+ 0.4 mm ,-0 mm at the end of 10 mm straight edge.

Thermit reaction details Aluminium reacts with iron oxides, particularly ferric oxide, in highly exothermic reactions, reducing the iron oxides to free iron, and forming a slag of aluminium oxide.

$3Fe_3O_4 + 8Al = 4Al_2O_3 + 9Fe$ (3088°C, 719.3kCal↑)

$3FeO + 2Al \Rightarrow Al_2O_3 + 3Fe$ (2500°C, 187.1kCal↑)

$Fe_2O_3 + 2Al \Rightarrow Al_2O_3 + 2Fe$ (2960°C, 181.5kCal↑)

SKV or SPW (Short pre-Heat welding)

Difference between Flash Butt and AT Welding

S.No	Description	Flash Butt Welding	A.T Welding
1	Principle of welding	Welding is done by passing of 5 volt, a 3500 ampere electric current between two rail ends	Welding done by an exothermic chemical reaction between Iron oxide and aluminium
2	Quality of Welding	Excellent	Good
3	Strength of Welding	Good in Fatique	Weak in fatigue
4	Time required for welding	About 3 to 6 minutes	50 minutes but normally a block of about 1 ½ hrs is required
5	Possible places for welding	Both Site and workshop but normally done in workshop	Welding at site
6	Tolerance	Very tight tolerance	Normal Tolerances
7	Cost of Welding	Rs 700 to 900 per weld	Rs 900 to 1200 per weld
8	Quality of Welding	By help of a welding recorder	Depends upon only by good work and no monitoring is possible

LWR

IMPORTANT DEFINITIONS:

1. **L.W.R. (Long Welded Rail):**
It is a welded rail, central part of which does not have any longitudinal movement due to temperature variation. Length of rail more than 250 meter in B.G. and 500 m. in M.G. should function as L.W.R.

2. **S.W.R. (Short Welded Rail):**
It is a welded rail, which contracts and expands throughout its length. It is generally three rail length long.

3. **Breathing Length:**
It is the length at each end of L.W.R. or C.W.R. which is subjected to contraction or expansion on account of variation in temperature.

4. **S.E.J. (Switch Expansion Joint):**
It is an expansion joint installed at each end of L.W.R.. to permit expansion or contraction of the adjoining breathing length due to temperature variation.

5. **Anchor Length:**
It is the length of the track required to resist the pull exerted on rail by rail tensor during distressing.

For B.G., Anchor length = La = 2.5 ($to^oc - tp^oc$) in meter.

For M.G., La = 4.5 ($to^oc - t^opc$) in meter

Where, to = stress free temperature.

o = Prevailing rail temperature.

6. **Destressing:**
The operation under taken with or without rail tensor to secure stress free condition in L.W.R. at a specified rail temperature is called destressing.

7. **Rail Temperature:**
It is the temp. of rail as recorded by an approval type of rail thermometer at site.

8. **Mean Rail Temperature :**
Mean rail temperature of section is the average of maximum and minimum rail temperature recorded for that section for last five years.

Mean rail temperature $t_m = \frac{Max^m \text{ Rail temp.} + Min^m. \text{ R.T.}}{2}$

Range Of Temperature:

= Max^m. Rail temp. – Min^m. Rail temp.

Ex. = $60^oC - (-10^oC)$

= 70^oC

Temperature map of Indian Railway shows the range of temperature and mean rail temperature of different places in India.

Ex. – Bombay 60^oC (20^oC)

Ze. Range of temperature = 60^oC

Mean Rail temperature= 20^oC

9. Prevailing Temperature:

It is the rail temperature prevailing at the time when any operation connected with de-stressing is carried out, denoted by to.

10. Stress Free Temperature (t_o):

It is the rail temperature at which the rail is free of all thermal stresses . At this temperature, there is no thermal stresses in the rail panel.

11. Destressing temperature (t_d):

It is the average rail temperature during the period of fastenings of rails to sleepers after de-stressing the L.W.R. without using tensor. If rail tensor are used, for all practical purpose, t_d can be taken as t_o. De-stresing temperature ranges are as follows.

Rail section		De-stressing temperature range (t_d-range)		
52 Kg & higher section	-	tm + 5	to	tm +10
other section	-	tm	to	tm +5

Permitted locations for LWR/CWR

A. General considerations for laying LWR/CWR –

1. LWR/CWR will be laid only those locations where the track structure and permitted locations confirms the condition of LWR manual.
2. New constructions/doubling/gauge conversions/permanent diversion shall be laid with LWR/CWR.
3. In goods running lines, goods yards, reception yards and classification yards, rail joints may be welded to form LWR if the condition of all the components of track is sound and without any deficiency. The approval of Chief Engineer is necessary for it.

B. Alignment

1. LWR/CWR shall not be laid on curves sharper than 440 meter radius both for BG and MG.
2. LWR/CWR may be continued through reverse curves not sharper than 875 metre radius, shoulder ballast of 600mm over a length of 100 metre on either side of common point should be provided.

C. Gradients

1. The steepest permitted grade shall be 1:100.
2. A vertical curve shall be provided at the junction of the grade when the algebraic difference between the grades is equal to more than 4mm per metre.
   The minimum radius of the vertical curve shall be kept as under
   For broad gauge

Group	Minimum radius
A	4000m
B	3000m
C,D,E	2500m

D. **Approval of Chief Engineer-** Installation of LWR/CWR shall have the approval of Territorial Chief Engineer.

E. LWR/ CWR shall not be laid in following locations-

1. Where rails are subjected to heavy wear, corrugation, corrosions or required to frequent renewals.
2. On weak formation where chances of deformation /settlement are more and it will lead the chances of buckling.
3. On weak/dirty soil where the pumping failures are more, resulting migration of soil into ballast and due to this frequent opening of ballast is more required.
4. On vulnerable locations of track where frequent flooding are more.

Track structure for LWR/CWR –

A. **Formation** – LWR/CWR shall be laid on stable formation.

B. **Ballast cushion**–

1. The minimum clean stone ballast cushion of 250mm shall be provided at the time of installation of LWR/CWR for the speed upto 130kmph.
2. For speed more than 130kmph, minimum ballast cushion should be 300mm.
3. Shoulder ballast should be **heaped 100mm**.

4. On straight track width of shoulder ballast cushion should be 350mm.
5. On sharp curve the width of shoulder ballast should be 500mm.
6. LWR/CWR may be continued through reverse curves not sharper than 875 metre radius, shoulder ballast of 600mm over a length of 100 metre on either side of common point should be provided.

C. **Sleeper and Fastenings** –

1. On broad gauge –
   i. Concrete sleepers with elastic fastenings
   ii. Steel trough sleepers with elastic fastening for speeds not exceeding 130 kmph
2. **Sleeper density** – The minimum sleeper density in LWR/CWR shall be follows-
   i. For zone 1 & 2 – (M+4) – 1340 sleepers per km
   ii. For zone 3 & 4 – (M+7) – 1540 sleepers per km

D. Rails -

1. In **one LWR**, two different rail sections are not permitted. In case of any change in rail section, LWR should be isolated by providing SEJ at junction point.
2. For BG the **allowed rail section are – 60kg, 52kg, 90R.**
3. The rail shall be **tested ultrasonically** and all defective rails replaced before conversion into LWR/CWR.
4. Rail ends which are bent, hogged, battered, or having history of bolt-hole cracks shall be cropped before welding for conversion into LWR/CWR.
5. New rails used in LWR/CWR shall, as for as possible be without fish-bolt holes.

E. Miscellaneous

1. **Continuity of track structure:** Wherever LWR/CWR is followed by fishplated track/SWR, **the same track structure** as of LWR/CWR shall be continued **for three rail lengths beyond SEJ.**
2. **Level crossings**: LWR/CWR may be continued through level crossing. But it should not be fall within the breathing lengths.
3. **Points and crossings**:
   i. LWR/CWR shall not normally continue through point and crossings. It should be isolated **with atleast three normal rail lengths**.
   ii. LWR/CWR may be continued through point and crossing but prior approval of RDSO required.

4. **Glued joints**: All insulations for track circuiting in LWR/CWR shall be done by providing glued joints G3 (L) types.
5. **Location of SEJ** :
    i. The exact location of SEJ shall be fixed taking into account the location of various obligatory points like level crossing, girder bridges etc.
    ii. Normally SEJ should be provided on straight track. If necessary it can be laid on curve but not sharper than 0.5 degree (3500 m radius) as far as possible.
6. **Bridges with ballasted deck**: LWR/CWR can be continued over bridges without bearings like slabs, box culverts and arches.
7. **Bridges without ballasted deck:**
    i. LWR/CWR may be continued through ballasted deck maximum length upto 30.5m and with condition as given in the manual.
    ii. Rail free fastening shall be used throughout the length of bridge.

Destressing

"In order to obtain the **stress free condition** in the weld rail panels and also to **nullify the internal stresses (Thermal stresses)** developed of the rail panel , the process which is carried out is known as the Destressing "

Destressing becomes necessary in following conditions :

1.) If LWR is not laid at distressing temperature .
2.) After the buckling and fracture repair.
3.) After deep screening / BCM working .
4.) After the long stretch track renewal work.
5.) After major realignment of curve.
6.) When the gap of the SEJ observe more than + 20 mm from the standard gap at t_d (40mm) or SEJ gap more than 120mm or tounge rail of the SEJ is disturbed from the mean position.
7.) When breathing length is increases more than the prescribed limit or when the movement under the non-breathing length portion is observed.
8.) After the accident if the track is disturbed .
9.) After the passing of the 10 GMT load on track or 1Year whichever is later or As per desire of the Chief Engineer.

Types of destressing :

There are two methods by which de stressing is carried out

1. Destressing without the use of Tensor
2. Destressing with the use of Tensor

Destressing without use of Tensor

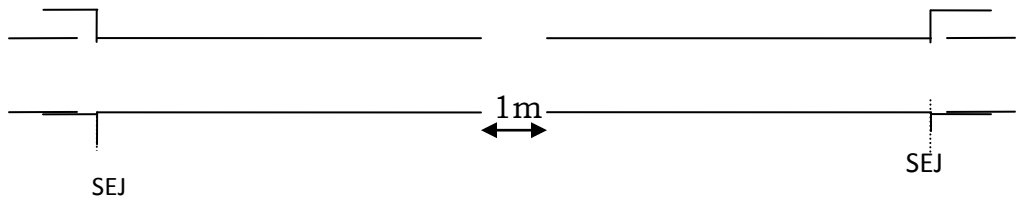
General :

1. The work of destressing shall be done during a traffic block under the personal supervision of a PWI.
2. It is preferable to impose a speed restriction of 30kmph before actually obtaining the traffic block and to loosen/remove fastenings on alternate sleepers to reduce total duration of the traffic block.

Factors to be considered for destressing :

1. **Designed Temperature :**
   The designed temperature for 52Kg and 60 Kg rail is
   (T_m+5) to (T_m+10)

2. **Time Period :**
   Destressing is carried out in those days of year when the designed value of temperature is achieved/ attended during the block the traffic block working time.
3. **Pre-Block arrangement :**



1.) Select first one Km of LWR for destressing first.
2.) **Caution** : Impose 30kmph caution for 1st one kilometre.
3.) Remove impedings/accesories to free movement of rail such as rail anchors, guard rails check rails etc.
4.) We have to provide a rail closure of one meter(or 4meter length as covinient)in centre of the LWR or first selected length of one kilometre (about500m from SEJ). It should be done in such a way that weld population is not increased. It should be properly fish plated/ bolted / clamped.
5.) All fittings and fastenings must be loosened/drew and50% fittings & fastenings of alternate sleepers should be removed.
6.) We keep 6meter to 6.5meter ultrasonically tested rails for final welding at the site where gap is created. We need to put **rail rollers** at both side of track at every 15 sleepers. Sufficient rubber pads and fastenings should be made available for replacing worn out ones .

4. Work During Block :

- ✓ Minimum 2 hours block shall be taken for de stressing.
- ✓ The temperature during the entire block period should fall under the desired destressing temperature i.e, (t_m+5 to t_m+10)
- ✓ One team should be provided at the start of the SEJ
- ✓ Five to six persons along with black smith and cutters should be provided at centre of first closure.
- ✓ If sufficient labour is available is available, the work of de stressing for next 500m. Also can be taken in same block otherwise only first 500m is destressed and second 500m shall be de stressed in next day block.
- ✓ Remove the rail closure from centre of both by removing fish plate and fittings.
- ✓ As soon as traffic block is started fittings and fastenings for first 500m of both rails should removed completely weld panel.
- ✓ Before the above step remove the rail closure from centre of both by removing fish plate and fittings.
- ✓ Put the rail pane on rail rollers. Freely tap both the panels for removing stress from one end to another (not from both). This locked up stresses are removed.
- ✓ The unserviceable fittings (rubber pads) should be removed by new ones (as we don't have to open it twice)
- ✓ Put back the rail panels and sleepers to original position.
- ✓ Adjust the SEJ gap (at standard td, SEJ= 40mm)
- ✓ Fasten the rail panel from SEJ to rail closure side (side where gap is there) in a unique direction.
- ✓ Record the temperature at fastening time.
- ✓ The gap between the rail panels should be increased/decreased depending on the nature of internal stresses present.
- ✓ Provide rail closure in between the track accordingly as required.
- ✓ Block will be cancelled.
- ✓ In next day de stressing of another 500m is done.
- ✓ Second day again block is taken at the time when required de stressing temperature is there,
- ✓ Again de stress the panel as done earlier.

NOTE :

De stressing of 2nd, 500m can also be done in same block if sufficient labour is there and sufficient time is available.

Final repair :

- ✓ After the de stressing, rail panel may expand/contract in different modules and according to this 6m rail gap shall be provided in place 4mrail closures.
- ✓ Provide total gap for providing :
  Rail length + two weld gap = 2m
  6m + 25mx2m = 2m
- ✓ Replace the rail, impose 30km caution for next 1km and carry out de stressing as earlier

Next Day's Block :

1. During the next day block both the rails shall be welded with two team of welders in diagonal method for providing working space.
2. After welding one joint, 2nd joint can also be welded considering the view of adjustment gap.

Equalisation of Forces :

After welding both joints equalisation of forces shall be done 100 metres at both sides at both panels, tapping and refastening it. Further whole length of LWR shall be de stressed int the same manner by providing gap at every 1km in stages.

- ✓ Finally after the de stressing, gap of the 2nd SEJ or both SEJ's shall be adjusted and hence de stressing work shall be completed

Final de stressing Temperature :

It shall be the average of the temperatures at the time of fastening of LWR

Equipments Required:

- ✓ All gang tools and blacksmith tools
- ✓ Rail cutting machines
- ✓ Qualified welders and two welding tools
- ✓ Portions of rail (60kg/52kg) of required rail section

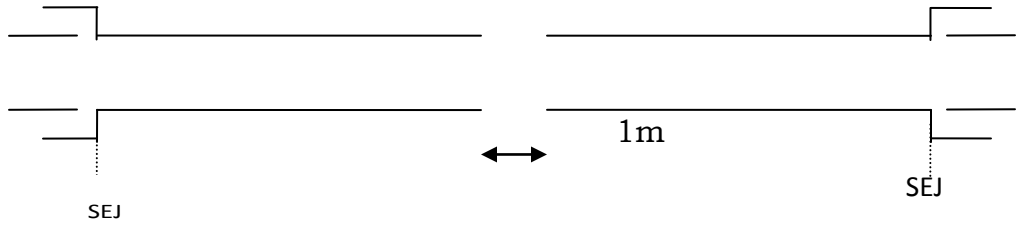
Destressing with rail tensor

General :

1. The work of destressing shall be done during a traffic block under the personal supervision of a PWI.
2. It is preferable to impose a speed restriction of 30kmph before actually obtaining the traffic block and to loosen/remove fastenings on alternate sleepers to reduce total duration of the traffic block.

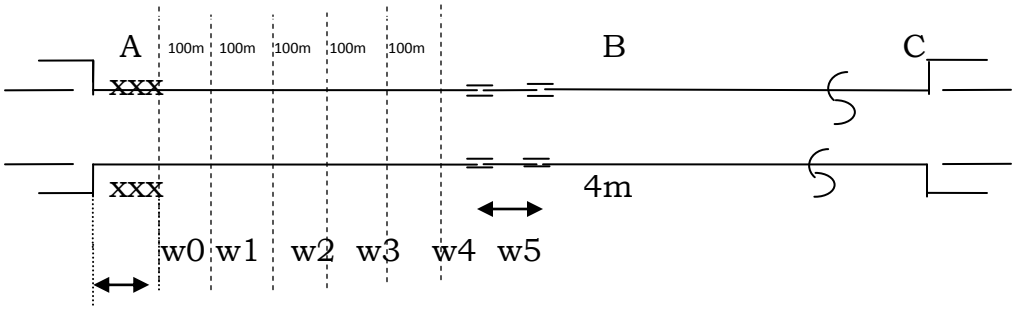
Factors to be considered for destressing :

5. **Designed Temperature :**
   The designed temperature for 52Kg and 60 Kg rail is
   (T_m+5) to (T_m+10)
6. **Time Period :**
   Destressing is carried out in those days of year when the designed value of temperature is achieved/ attended during the block the traffic block working time.
7. **Pre-Block arrangement :**



1. Select first one Km of LWR for destressing first.
2. **Caution** : Impose 30kmph caution for 1st one kilometre.
3. Remove impedings/accessories to free movement of rail such as rail anchors, guard rails check rails etc.
4. We have to provide a rail closure of one meter(or 4meter length as convenient)in centre of the LWR or first selected length of one kilometre (about500m from SEJ). It should be done in such a way that weld population is not increased. It should be properly fish plated/ bolted / clamped.
5. Decide Anchor length adjacent to SEJ with formula
   i. **Anchor length = 2.5Δt**
6. Leaving **Anchor length** , all fittings and fastenings must be loosened/drew and50% fittings & fastenings of alternate sleepers should be removed.
7. We keep 6meter to 6.5meter ultrasonically tested rails for final welding at the site where gap is created. We need to put **rail rollers** at both side of track at every 15 sleepers. Sufficient rubber pads and fastenings should be made available for replacing worn out ones.

During the first traffic block :-



1.) Take a traffic block .
2.) Create a gap of 1meter at location B' at a distance of about half the length of LWR from the center of S.E.J .
3.) Introduce rail closure as required and fasten with special fish plate and clamps .Allow traffic at a restricted speed. (Impose a caution of 30 KMPH)
4.) Mark the anchor length :-

For 52 Kg rail -----A_1A_2=la =2.5 meter per degree Celsius at (t_d-t_p)

Note :

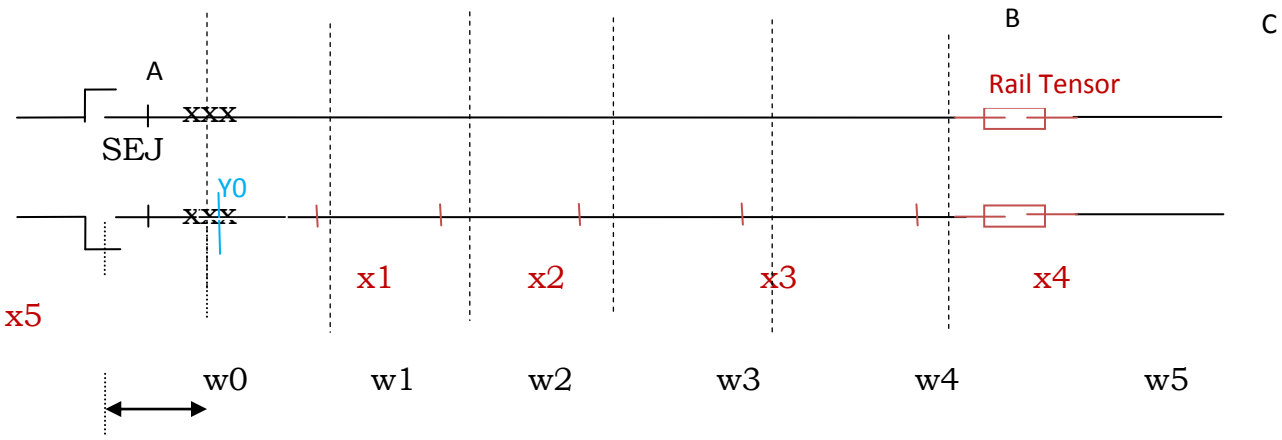
$\Delta \mathbf{l = L\alpha\Delta t}$ Where

Δt = (t_d-t_p) and α = co-efficient of thermal expansion

a.) Anchoring of panel must provide a force greater than the pulling force
b.) The anchoring length should be determined on the bar is of the lowest value of t_p at which the distressing is likely to be carried out.
5.) Erect Marker pillar W0, W1, W2 set on each of the length A to B at a interval of 100 meters.
6.) Transfer the mark W0 to the rail flange with the help of a chord.
7.) The distance W0 to W1 and W1 to W2 be marked at a interval of 100 meters.
8.) The last length W4 to W5 may be less than 100 meters.

During second traffic block

1. During the second traffic block , When the $t_p$is less than t_d . Carryout the destressing within the length A&B as below.



2. Remove the rail closure from the location B. Unfasten and mount the rails on rollers (at every 15th sleeper) in position A to B .
3. Fix the rail tensor across the location B . Apply the tension till the point W0 moves . Kinks and misalignment will be removed and friction on rollers will be minimized . Release the tension and note the movement Y0 to W0.
4. Transfer the mark W1,W2,W3,W4& W5 on the rail with closure pencils.
5. Obtain the required extension at W1 noting (t_p) at W1 and calculating the extension as under :-
    i. Extension at W1 = Y0 + 100α(t_d-t_p) = x1 (say)
    ii. Extension at W2 = Y0 + 200α(t_d-t_p) = x2(say)
    iii. Extension at W3 = Y0 + 300α(t_d-t_p) = x3 (say)
    iv. Extension at W4 = Y0 + 400α(t_d-t_p) = x4 (say)
    v. Extension at W5 = Y0 + 500α(t_d-t_p) = x5 (say)
    vi. The value of 100α(t_d-t_p) is available in the annexure IX of manual
6. Mark the x1 from W1 backward with a different colour pencil. Pull the tensor till the mark x1 coincides with W1 exactly . Now stop the tensor and remove the rollers W0&W1 and fasten the sleeper upto W0 to W1.
7. Proceed to part W2 and again pull tensor till the coincides of the X2 with W2 exactly. Now again stop the tensor and remove the rollers W1&W2 and fasten the sleeper between W1 toW2.
    Similarly proceed upto W5.
8. Now tensor will be released and new rail closure will be put inside the gap.Caution will still be 30 Kmph.

9. In the **next block** (May be next day), next 500m (Portion C) will be distressed as per the above procedures.

Welding work:

1. After the de stressing, rail panel may expand/contract in different modules and according to this rail gap shall be provided in place 4m rail closures.
2. Provide total gap for providing :

   Rail length + two weld gap – 1mm {6m + (25mm x 2) – 1mm}

3. Replace the rail.
4. During the next block, both the rails shall be welded with two team of welders in diagonal method for providing working space.
5. After welding one joint, 2nd joint can also be welded considering the view of adjustment gap.
6. **Equalisation of Forces :**After welding both joints equalization of forces shall be done 100 metres at both sides at both panels, tapping and refastening it.
7. **Further whole length of LWR shall be de stressed in the same manner by providing gap at every 1km in stages.**
8. **SEJ Gap adjustment :-**Finally after the de stressing, gap of the 2nd SEJ or both SEJ's shall be adjusted and hence de stressing work shall be completed

Rail fracture on LWR

Cause:

1. Existing flaw undetcted.
2. Defective Welding.
3. De-Stressing ignored.
4. Not observing the instructions in maintenance.
5. Flat tyre of running train.

RECTIFICATION OF RAIL FRACTURE

Equipments required:

1. Screw clamp, joggle fish plate for fracture rail welded joint and special 1m long fish plate.
2. Steel tape for reading up to 1mm.
3. AT welding and filling equipments.
4. Punch and hammer.
5. Equipments for De-stressing.
6. 4m long swan rail cut piece of the same rail section (This length will usually do exception like of fracture between to welds very close together in a short piece of rail are not calculated here.)
7. Rail closure: 30mm long
8. Equipments for protection of track.
9. Equipments for right working.

Action to be taken when rail fracture in LWR reported

1. Stop the traffic (It should be stop by keyman/mate/gangman).
2. Emergency repair (mate/keyman are authorized) then stop the train at restricted speed .that is first train at stop dead and 10 kmph but subsequent train at 15 kmph.
3. Temporary repair.
4. Permanent repair.
5. Equalization of forces in 100m length in either side.

PROCEDURE OF REPAIRS

Immediate action: Stop the traffic in emergency and protect the track with engineering signals.

The repair work will be carried out in following four steps.

1. Emergency repair
2. Temporary repair
3. Permanent repairs
4. Equalization of forces

1. Emergency repair (Fish plating)

The emergency repair is carried out immediately just after the detection of fracture by keyman/gangman on duty in following step as given below:

I. Joggle Fish plate/fish plate should be provided at weld/rail fracture.

II. If there is a gap in fracture more than 30 mm , insert the 30mm rail piece in the gap. Fasten it with special fish plate and clamps. In case of weld failures use a joggled fishplate.

III. Provide a wooden block to support at the fracture.

IV. After providing joggle /fishplate and wooden block support, pass the traffic as under:

First train with stop dead and proceed at 10kmph.

V. Memo/message should be sent to the nearest Station Master for information of the fracture and subsequent train passing with non-stop 15kmph speed restriction.

Note:

1. If the fracture is **multiple fracture** or any other **critically** is there and it is difficult to pass the traffic, the message of requirements shall be given to sectional JE/SSE through Driver of the train and Station Master. Message also can be sent by mobile phone.

2. Traffic will pass only after the Emergency Repair.

3. The work is to be supervised by mate/keyman or any other official.

4. Keyman/Mate shall not leave the site till arrival of the supervisory staff. After passage of each train he will check the fracture /repair and it will permit then pass the next train.

2. Temporary repair (Rail replacement)

i. Ultrasonically tested rail piece is taken. (Not less than 4m Length).

ii. Arrange a traffic block as early as possible for minimum 30 minutes.

iii. Make two punch box on the either side of the gap at a distance

l=L+G+2W-1mm (saw cut)

Where,

l= Distance Mark
L= Rail Closure Length
G= Gap between rail at fracture point
W = Weld Gap (25mm)

iv. Now cut the rail at punch mark and remove the broken piece.

v. Insert the USFD tested rail piece inside the gap. (Principal is metal taken out = metal put in). Distribute the gap either side and if it is found to be more than 30mm, insert a rail piece of 30mm.

vi. Fasten the new rail in track with special fish plate and clamp/bolts.

vii. Remove the traffic block and **pass the traffic with 30kmph.**

Note: While making the punch mark, be ensure that there is no welds existing on outside within 4 meter.

3. Permanent repairs (Welding of joints)

i. Take the traffic block preferably at a temperature lower than t_d and close to t_d.

ii. Make a gap of 25mm at one end of rail piece and weld it.

iii. If it is found that at the other end also a gap of 25mm is available. This can also be welded simultaneously at the same time.

iv. In case 25 mm gap is not available at other end than take another traffic block at the temperature t_p, lower than t_d. Remove the fastening for some distance on either side, raise the rails on rollers and with the help of rail tensors, pull the rail across the gap to obtain of 25mm.

v. Release the tensor **20 minutes** after the welding so that it cools down.

vi. After release the tensor fasten the rail completely and allows the traffic 30kmph.

4. **Equalization of forces(Local De-stressing)**:

i. De-stress 100meter on either side of fracture portion manually by removing fastenings, tapping and refastening the rails for **distribution of locked up thermal stresses** produce due to welding .

ii. But it is better to be done within a block when t_p is less than t_d.
iii. Then allow **normal traffic**.

BUCKLING OF TRACK IN LWR/CWR

Causes:

1. Loose or missing fittings
2. Loss of ballast resistance (lateral and longitudinal).
3. Locked up internal stresses.
4. Wrong laying not followed by de-stressing.

Vulnerable Locations:

1. Approach of the level crossing.
2. Approach of the girder bridge.
3. Approach of the tunnel.
4. Breathing length.
5. Location where track structure is change.
6. Sharp curve/revese curve .

INDICATION:

1. Lifting of track.
2. Development of sun kinks.
3. Development void/gap around the sleepers.

REPAIR OF BUCKLED TRACK

Immediate action: Stop the traffic immediately and protect the track with engineering signals

The repair work will be carried out in following four steps.

1. Emergency repair
2. Permanent repairs
3. Equalization of forces/Destressing & packing

1. EMERGENCY REPAIR: -

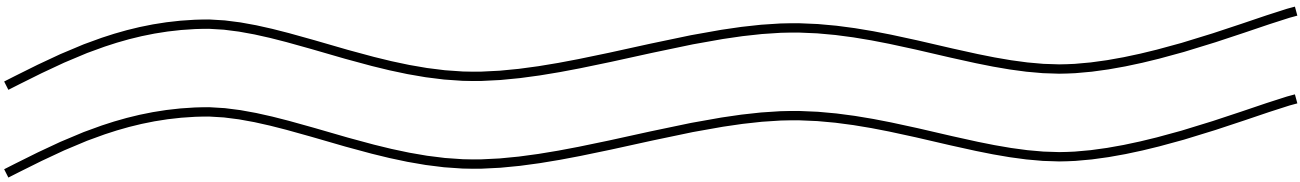


Fig. 1

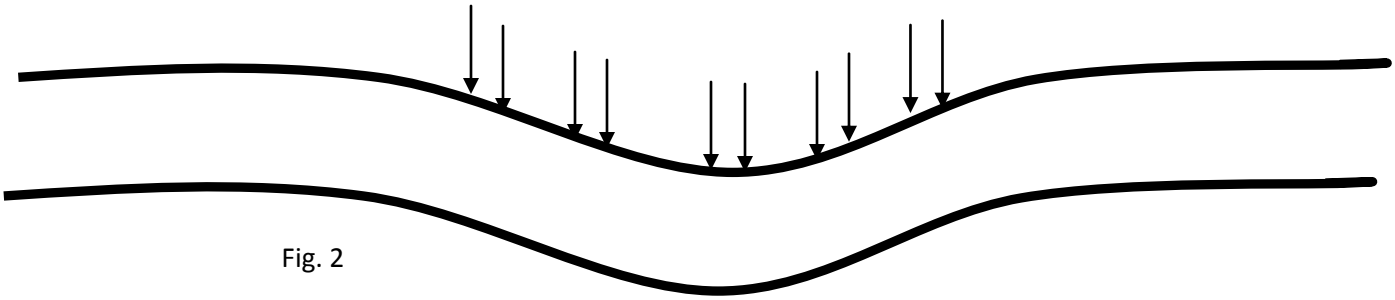


Fig. 2

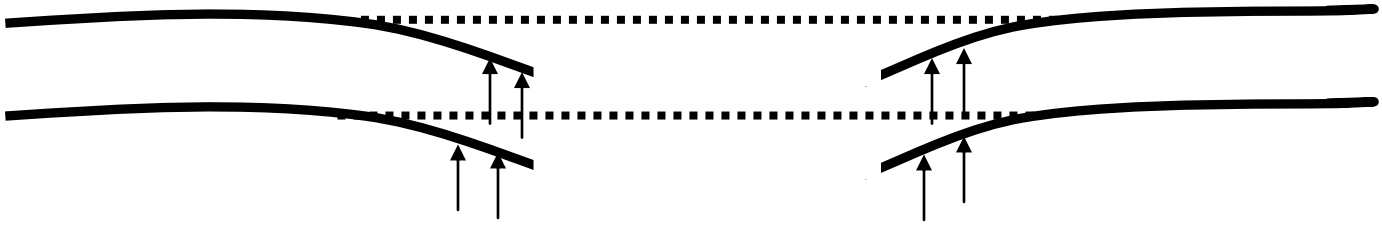


Fig. 3

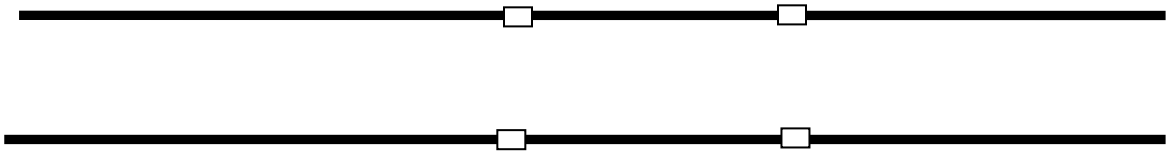


Fig .4

i. The buckled rail should be released of compression by slewing the track outwards side. (Fig.2)
ii. The rail on left hand side as well as right hand side, will be cut at two places to ensure that the gap may not less than 4.(Fig. 3)
iii. Put back the normal alignment. (Fig. 3)
iv. These gaps will be closed by providing two USFD tested rail pieces, keeping provision of two A.T. welds on either side.(Fig. 4)
v. It will be fastened by special fish plate and clamp.
vi. At least one round packing should be done to ensure gauge and cross level etc.
vii. After this, traffic can be **resumed at a restricted speed preferably at 20kmph on PRC sleepers and 10 kmph on other sleepers**

2. PERMANENT REPAIRS: -

i. Make a gap of 25mm at one end of rail piece and weld it.
ii. If it is found that at the other end also a gap of 25mm is available. This can also be welded simultaneously at the same time.
iii. In case 25 mm gap is not available at other end than take another traffic block. Remove the fastening for some distance on either side, raise the

rails on rollers and with the help of rail tensors, pull the rail across the gap to obtain of 25mm.

iv. Release the tensor **20 minutes** after the welding so that it cools down.

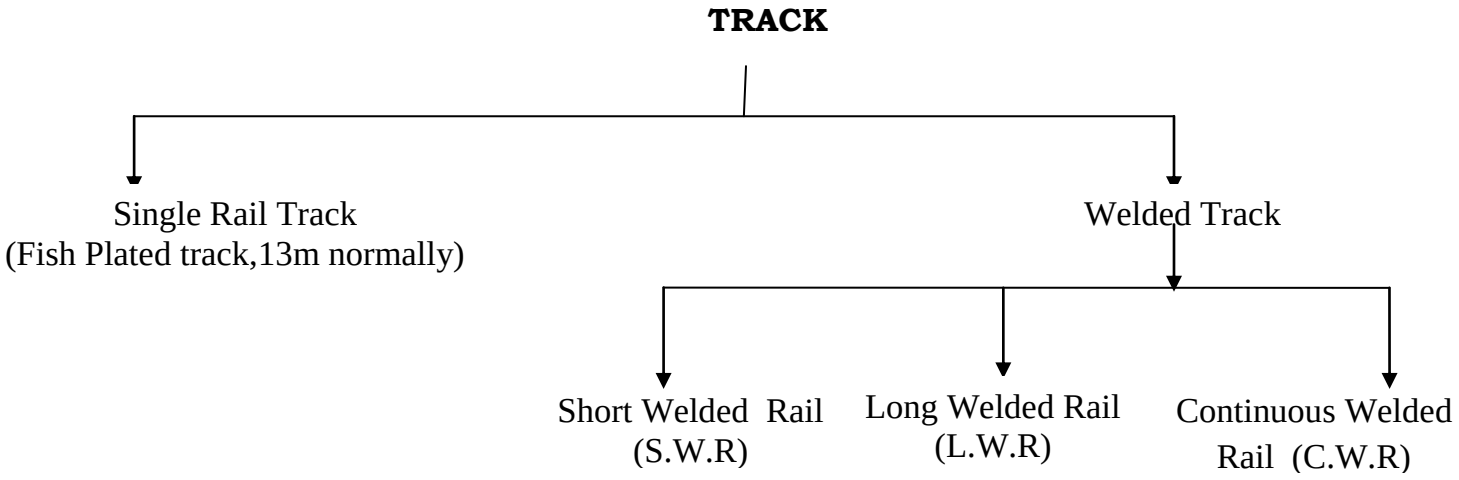
v. At least one or two round manual/machine packing of the buckled portion should be done and allow the traffic 30kmph.

3. DE-STRESSI NG & PACKING: -

i. After the permanent repair, the entire LWR will have to be de-stress as per LWR manual.

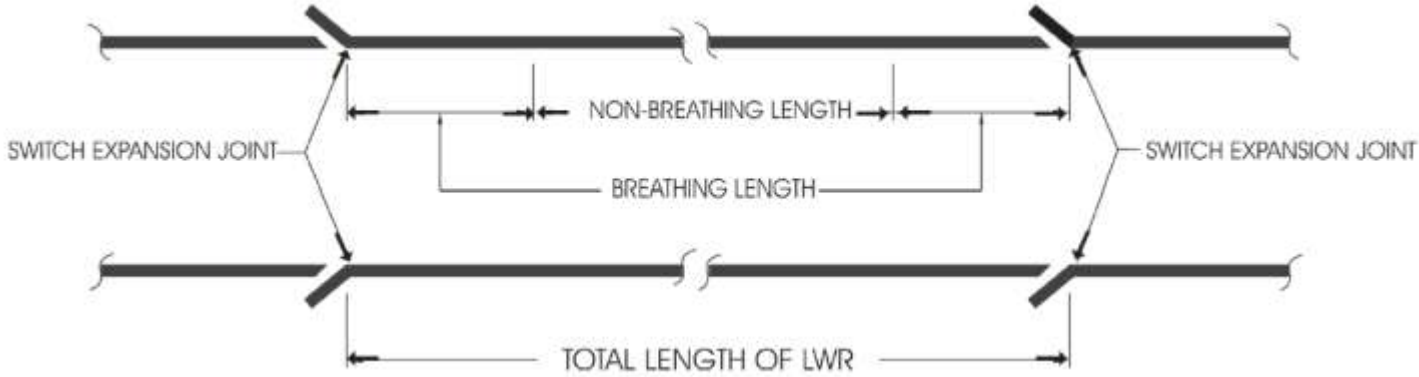
ii. Resume the normal speed after several round of packing/tamping and stabilization of track.

RAILWAY TRACK:



Long Welded Rail (LWR) is a welded rail, the central part of which does not undergo any longitudinal movement due to temperature variations. A length of greater than 200 metre on Broad Gauge (BG) and 500 metre on Metre Gauge (MG) will normally function as LWR

Note : The maximum length of LWR under Indian conditions shall normally be restricted to one block section.



Continuous Welded Rail (CWR) is a LWR which would continue through station yards including points and crossings.
Short Welded Rail (SWR) is a welded rail, which contracts and expands throughout its length.

Note: Normally the length of SWR is 3 x 13 metre for BG and 3 x 12 metre for MG.

Breathing Length is that length at each end of LWR/CWR, which is subjected to expansion/contraction on account of temperature variations.

Note: Usual breathing lengths in BG and MG for different types of track structures and for
different temperature zones,

The breating length depends on the following :

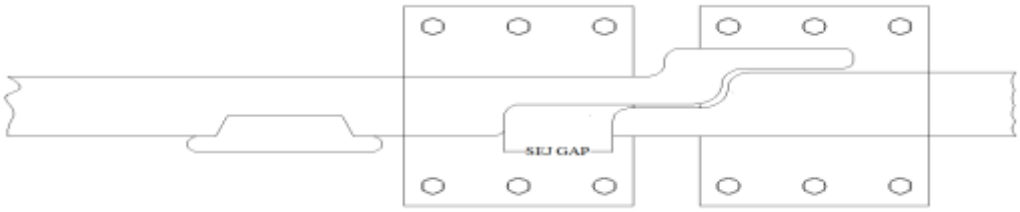
1. Type of rail
2. Type of sleeper
3. Sleeper density
4. Type of fastenings used
5. Maximum Temperature Variations

Usual Breathing Length in IR is as follows (on PRC Sleepers on BG Track)

Zone	Sleeper Density	Rail Type	Breathing Length (in metres)
I	M + 8	60 Kg	58
		52 Kg	50
	M +7	60 Kg	60
		52 Kg	52
II	M + 8	60 Kg	66
		52 Kg	57
	M +7	60 Kg	69
		52 Kg	59
III	M + 8	60 Kg	74
		52 Kg	64
	M +7	60 Kg	77
		52 Kg	66
IV	M + 8	60 Kg	79
		52 Kg	68
	M +7	60 Kg	82
		52 Kg	71

Switch Expansion Joint (SEJ) is an expansion joint installed at each end of LWR/CWR to permit expansion/contraction of the adjoining breathing lengths due to temperature variations

Where there are isolation is required they are done in three rails of three meter length of Buffer rails. These buffer rail has 6mm gap and has 7 joints. So 7 x 6 = 42mm gap is attained easily



SEJ GAP = 40 ±2 mm

Buffer Rails are, a set of rails provided in lieu of SEJ at the ends of LWR/CWR to allow expansion / contraction of adjoining breathing lengths due to temperature variations. These will be laid with prior approval of Chief Engineer at locations where provision of SEJ is not permitted. Buffer rails may also be temporarily laid to facilitate maintenance/renewal operations.

GAPS AT SEJ

Gaps at SEJ shall be adjusted at the time of laying/subsequent distressing of LWR/CWR, as illustrated

Rail section laid	**Gap to be provided at 'td'**
52kg/60kg	40 mm
Others	60 mm

Rail Temperature is the temperature of the rail at site as recorded by an approved type of rail thermometer as laid down. This is different from ambient temperature which is the temperature of air in shade at the same place.

ZONE	**I**	**II**	**III**	**IV**
Maximum Range of Temperature	40°C to 50°C	51°C to 60°C	61°C to 70°C	71°C to 76°C

Mean Rail Temperature (t_m) for a section, is the average of the maximum and minimum rail temperatures recorded for the section.

Destressing is the operation undertaken with or without rail tensor to secure stress free conditions in the LWR/CWR at the desired/specified rail temperature.

Destressing Temperature (t_d) is the average rail temperature during the period of fastening the rails to the sleepers after distressing LWR without the use of rail tensor. If rail tensor is used, td for all practical purposes is equal to t_o. Range of t_d or t_o shall be within the limits of rail temperature shown below:-

Rail Section	**Range**
52kg & heavier	t_m+5^0C to t_m+10^0C
Others	t_m to t_m+5^0C

Installation Temperature (t_i) is the average rail temperature during the process of fastening the rails to the sleepers at the time of installation of the LWR/CWR.

Prevailing Rail Temperature (t_p) is the rail temperature prevailing at the time when any operation connected with destressing is carried out.

Stress-free Temperature (t_o) is the rail temperature at which the rail is free of thermal stress. When tensors are utilised for the destressing operation the work has to be carried out at tp, which shall be lower than stress-free temperature. The extension to be applied by the tensor shall be calculated from the following formula:-

Extension = L α (to - tp)

where 'L' is the length of segment of the rail to which the extension is applied

' α ' is the coefficient of linear expansion of rail steel.

Rail Tensor is a hydraulic or mechanical device used for stretching the rail physically.

Anchor Length (l_A) is the length of track required to resist the pull exerted on rails by the rail tensor at temperature tp. For practical purposes, this may be taken as equal to 2.5 metre per degree celsius of (t_o - t_p) for BG and 4.5 metre per degree celsius of (t_o - t_p) for MG.

Hot Weather Patrol is the patrol carried out when the rail temperature exceeds t_d + 20^0C.

Cold Weather Patrol is the patrol carried out during cold months of the year in specified sections as per instructions of Chief Engineer.

Consolidation of Track is the process of building up ballast resistance to the tendency of movement of sleeper either initially before laying LWR or making up subsequent loss of resistance by anyone of the following:-

i) For track structures consisting of sleepers other than concrete sleepers

a) Passage of at least 3,00,000 gross tonnes of traffic on BG or at least 1,00,000 gross tonnes of traffic on MG when compaction of ballast is done using hand operated compactors/consolidators or rammers.

b) Passage of at least 50,000 gross tonnes of traffic on BG or at least 20,000 gross tonnes of traffic on MG or a period of two days, whichever is later, when compaction is done by means of mechanised shoulder and crib compactor.

ii) For the track structure consisting of concrete sleepers, passage of at least 50,000 gross tonnes of traffic on BG or at least 20,000 gross tonnes of traffic on MG or a period of two days whichever is later.

iii) Atleast one round of stabilisation by Dynamic Track Stabiliser (DTS).

i) For newly laid LWR/CWR, at least three rounds of packing, last two of which should be with on-track tamping machines.

THERMAL FORCES IN LWR/CWR: Temperature changes cause movement of the ends of LWR/CWR in the breathing lengths but the central portion of LWR/CWR does not expand/contract. This results in building up of thermal

forces in the central portion. The thermal force (P) calculated below, is to be resisted by suitable track structure.

$P = E A \alpha t$

where, P = Thermal force in the rail (kg)

E = Modulus of elaticity of rail steel, (2.15×10^6 kg/ cm^2)

α = Coefficient of linear expansion of steel, (1.152×10^{-5} ^{0}C)

A = Area of cross section of the rail (cm^2)

t = Variation of rail temperature from t_d /t_o (^{0}C)

Temperature changes cause movement of the ends of LWR/CWR in the breathing lengths but the central portion of LWR/CWR does not expand /Contract. This results in building up of thermal forces in the central portion. The thermal force(p) calculated below is to be resisted by suitable track structure.

In winter Rail is Fractured

In Summer Rail is Buckled

Symptoms of Buckling

1. Sun Kinks

PERMITTED LOCATIONS FOR LWR/CWR

GENERAL CONSIDERATIONS FOR LAYING LWR/CWR

1. As a rule, complete track renewals (Primary) shall provide for LWR/CWR wherever permissible by the provisions of this Manual. Also existing rails on permitted locations may be converted into LWR/CWR, provided they meet the requirements laid down in the Manuals for Welding of Rail Joints by Alumino - Thermic (SKV Process)/Gas Pressure/Flash Butt Process, as the case may be.
2. New constructions/doublings/gauge conversions/retired alignment/permanent diversion shall be opened with LWR/CWR, wherever permissible by the provisions of this Manual.
3. In goods running lines, goods yards, reception yards and classification yards, rail joints may be welded to form LWR if the condition of all the components of track is generally sound and without any deficiency, subject to such relaxation as may be approved by Chief Engineer, in each specific case/Issue.

ALIGNMENT

1. LWR/CWR shall not be laid on curves sharper than 440 metre radius both for BG and MG.
2. LWR/CWR may be continued through reverse curves not sharper than 875 metre radius. For reverse curves sharper than 1500 metre radius,

shoulder ballast of 600mm over a length of 100 metre on either side of the common point should be provided.

GRADIENTS

1. The steepest permitted grade shall be 1:100.
2. A vertical curve shall be provided at the junction of the grade when the algebraicdifference between the grades is equal to or more than 4 mm per metre or 0.4 percent,

.

The minimum radius of the vertical curve shall be kept as under:

Broad Gauge		**Metre Gauge**	
Group	Minimum radius in metre	Group	Minimum radius in metres
A	4000	All routes	2500
B	3000		
C, D & E	2500		

Approval of Chief Engineer : Installation of LWR/CWR or change in its constitution at a later stage shall have the approval of the Territorial Chief Engineer concerned in each case, on a detailed plan prepared. However, for any deviation from the provisions of this Manual, the approval of Chief Engineer shall be obtained.

LWR/CWR shall not/Cannot be laid on following Locations

1. Where rails are subjected to heavy wear, corrugation, corrosions are required to frequent renewal (Costal Area's)
2. On weak formation where chances of de-formation / Settlement are more and it will lead to the chances of buckling
3. On weak/dirty soil where pumping failures are more resulting migration of soil into ballast and due to this frequent opening of ballast is more required.
4. On vulnerable locations of track like the locations where frequent floodings are more.

TRACK STRUCTURE FOR LWR/CWR

FORMATION

LWR/CWR shall be laid on stable formation. Formation width shall be conforming to the extant instructions.

BALLAST CUSHION AND SECTION:

The minimum clean stone ballast cushion (below the bottom of the sleeper) of 250 mm shall be provided at the time of installation of LWR/CWR. Where speeds in excess of 130 km/h on BG or 100 km/h on MG are to be introduced, at least 300 mm ballast cushion or 200 mm ballast cushion over 150 mm of sub-ballast shall be provided.

The ballast section and cushion provided for LWR/CWR shall be continued over SEJ and upto 3 rails beyond it wherever it is followed by SWR/fish plated track.

SLEEPERS & FASTENINGS

Following types of sleepers and fastenings are approved for use in LWR/CWR:-

On Broad Gauge

i) Concrete sleepers with elastic fastenings

ii) Steel trough sleepers with elastic fastenings for speeds not exceeding 130 km/h (as an interim measure speed up to 160 km/h may be allowed)

On Metre Gauge

Preferably for speeds above 75 km/h but a must forspeeds above 100 km/h.	For speeds not exceeding 100 km/h.
Concrete sleepers with elastic fastenings, Steel trough sleepers with elastic fastenings	ST sleepers with keys, CST-9 sleepers with keys

Notes:

i. LWR/CWR already existing on steel trough sleepers and CST-9 sleepers with key fastenings for speeds upto 130 km/h on BG, if behaving satisfactorily, may be continued.

ii. On steel trough sleepers with key fastenings, the breathing lengths shall preferably be provided with elastic fastenings.

iii. Existing LWRs/CWRs on wooden sleepers with anti creep bearing (ACB) plates & two way keys or elastic fastenings, if behaving satisfactorily, may be continued for maximum speed of 130 km/h on BG and 100 km /h on MG.

Sleeper density

The minimum sleeper density (number of sleepers/km) in LWR/CWR shall be as follows:-

Types of sleeper	**Sleeper density (BG/MG)**
PRC Sleeper	1310 in temperature Zones I & II
PRC Sleeper	1540 in temperature Zones III & IV
Other sleepers	1540 in all temperature Zones

RAILS

i) Rails of the following sections shall be welded into LWR/CWR:-

Gauge	**Rail section**
BG	90R/52kg/60kg
MG	75R/90R

LWR/CWR already laid with 60R rails on MG may be allowed to continue.

ii) In one LWR, two different rail sections are not permitted. In case of any change in rail section, LWR should be isolated by providing SEJ.

While converting existing fish plated /SWR track into LWR/CWR, following precautions shall be taken:-

i) The rails shall be tested ultrasonically and all defective rails replaced before conversion into LWR/CWR.

ii) Rail ends which are bent, hogged, battered, or having history of bolt-hole cracks shall be cropped before welding for conversion into LWR/CWR.

iii) In case of LWRs laid on concrete sleepers having different rail section on either side of SEJs, instead of providing three normal rail lengths of each rail section between SEJs, two 3 rail panels, one of each rail section shall be provided with combination fish plated joint, between the two panels.

New rails used in LWR/CWR shall, as far as possible be without fish-bolt holes. Joining of rail ends temporarily during installation of LWR/CWR shall be done by 1 metre long fishplates with special screw clamps/joggled fish - plates having slotted grooves & bolted clamps with speed restrictions indicated in Annexure-III. Fish-bolt holes if any, shall be chamfered.

MISCELLANEOUS

Continuity of track structure: Wherever LWR/CWR is followed by fish plated track/SWR, the same track structure as that of LWR/CWR shall be continued for three rail lengths beyond SEJ.

Level crossings: Level crossings situated in LWR/CWR territory shall not fall within the breathing lengths.

Points and Crossings: LWR/CWR shall not normally be taken through points and crossings. Three normal rail lengths shall be provided between stock rail joint (SRJ) and SEJ as well as between the crossing and SEJ. These normal rail lengths shall be provided with elastic rail clips/anchors to arrest creep. However,where concrete sleeper turnouts are laid, instead of three normal rail lengths, one

three rail panel shall be provided between SEJ and SRJ as well as between heel of crossing and SEJ.

LWR/CWR shall not be taken through points & crossings. For any exceptions in this regard, special arrangements shall have the prior approval of RDSO.

Glued Joints: All insulations for track circuiting in LWR/CWR shall be done by providing glued joints G3(L) type.

Location of SEJ: The exact location of SEJ shall be fixed taking into account the location of various obligatory points such as level crossings, girder bridges, points and crossings, gradients, curves and insulated joints. SEJ with straight tongue and stock shall not be located on curves sharper than 0.5 degree (3500 m radius) as far as possible. SEJ shall not be located on transition of curves.

Bridges with ballasted deck (without bearing): LWR/CWR can be continued over bridges without bearings like slabs, box culverts and arches.

Bridges with/without ballasted deck

i) LWR/CWR shall not be continued over bridges with overall length as specified in para1 for BG and not more than 20 metre for MG.

ii) Bridges on which LWR/CWR is not permitted/provided shall be isolated by a minimum length of 36 metre well anchored track on either sides.

Para 1

i) Bridges provided with rail-free fastenings (single span not exceeding 30.5 metre and having sliding bearings on both ends)

Overall length of the bridge should not exceed the maximum as provided in Table-1 with following stipulations:-

a) Rail-free fastenings shall be provided throughout the length of the bridge between abutments.

b) The approach track upto 50 m on both sides shall be well anchored by providing any one of the following:-

a. ST sleepers with elastic fastenings
b. PRC sleepers with elastic rail clips with fair 'T' or similar type creep anchors.

c) The ballast section of approach track up to 50 metre shall be heaped up to the foot of the rail on the shoulders and kept in well compacted and consolidated condition during the months of extreme summer and winter.

ii) Bridges provided with rail-free fastenings and partly box-anchored (with single span not exceeding 30.5 metre and having sliding bearings at both ends)

Overall length of the bridge should not exceed the maximum as provided in Table-1 with following stipulations:-

a) On each span, 4 central sleepers shall be box-anchored with fair 'V' or similar type creep anchors and the remaining sleepers shall be provided with rail-free fastenings.

b) The bridge timbers laid on girders shall not be provided with through notch but shall be notched to accommodate individual rivet heads.

c) The track structure in the approaches shall be laid and maintained to the standards as stated in item (i) (b) and (c) above.

d) The girders shall be centralised with reference to the location strips on the bearing, before laying LWR/CWR.

e) The sliding bearings shall be inspected during the months of March and October each year and cleared of all foreign materials. Lubrication of the bearings shall be done once in two years.

TABLE - 1

Maximum overall length of bridges permitted on LWR/CWR on BG (in metre)((i) & (ii))

Temperature zones	Rail section used	Rail-free fastenings on bridges 1 (i)	Rail-free fastenings on bridges andpartly box-anchored 1 (ii)
		Type of sleeper used in approaches PRC/ST	Type of sleeper used in approaches PRC/ST
I	60 Kg	30	**77**
	52 Kg/90 R	45	**90**
II	60 Kg	11	**42**
	52 Kg/90 R	27	**58**
III	60 Kg	11	**23**
	52 Kg/90 R	27	**43**
IV	60 Kg	11	**23**
	52 Kg/90 R	27	**43**

iii) Welded rails may be provided from pier to pier with rail-free fastenings and with SEJ on each pier. The rail shall be box-anchored on four sleepers at the fixed end of the girder if the girder is supported on rollers on one side and rockers on other side. In case of girder supported on sliding bearings on both sides, the central portion of the welded rails over each span shall be box-anchored on four sleepers.

iv) LWR/CWR may also be continued over a bridge with the provision of SEJ at the far end approach of the bridge using rail-free fastenings over the girder bridge. The length of the bridge in this case, however, will be restricted by the capacity of the SEJ to absorb expansion, contraction and creep, if any, of the rails. The length of the bridges with the above arrangement that can be permitted in various rail temperature zones for LWR/CWR with SEJs having maximum movement of 120 mm and 190 mm are as follows:-

Max movement of SEJ used (mm)	Rail Temp Zone	Max. length of bridge with SEJ		Initial gap to be temp. provided at t_d	
		With ST/PRC approach sleepers	With CST-9 approach sleepers	With ST/PRC approach sleepers	With CST-9 approach sleepers
190	I	160	150	6.5	6.0
	II	110	100	6.5	6.5

	III	70	70	7.0	6.5
	IV	55	45	7.0	6.5
120	II	20	15	4	4
	I	50	50	4	4

***Note** SEJ is to be installed 10 metre away from the abutments**:**.*

iv) Welded rails may be provided over a single span bridge with rail free

v) fastenings and SEJs at 30m away from both abutments. The rail shall be box anchored on four sleepers at the fixed end of the bridge if bridge is supported on rollers on one side and rockers on other side. In case of bridge supported on sliding bearings on both sides, the central portion of the welded rails shall be box anchored on four sleepers. On both side of approaches fully creep anchored fastening shall be used.

The length of single span bridge permitted temperature zone-wise shall be as under:

Temperature Zone	Maximum length of single span girder bridge with SEJ (190mm gap) at 30m away from both abutments with full creep resistant fastenings at approaches (td = tm)
IV	75m
III	87m
II	110m
I	146m

DESTRESSING OF LWR

General:

i) The work of destressing shall be done during a traffic block under the personal supervision of a PWI.

ii) It is preferable to impose a speed restriction of 30 km/h before actually obtaining the traffic block and to loosen/remove fastenings on alternate sleepers to reduce total duration of the traffic block.

Sequence of operations:

The procedure to be adopted for destressing consists of the following steps:-

i) Remove impediments to free movement of rail such as rail anchors, guard rails, check rails etc.

ii) Create gap of about 1 metre at the centre of LWR during a traffic block and insert a closure rail there at a restricted speed.

iii) Mark anchor lengths at either end of the proposed LWR in accordance

Notes:

a) Anchor length shall be determined on the basis of the lowest value of t_p at which destressing is likely to be carried out.

b) Anchor length shall be increased suitably if the fastenings, rubber pads, liners or ballast conditions are poor.

iv) Erect marker pillars at the ends of anchor lengths on either side and at 100 metre intervals thereafter.
v) Obtain a traffic block when tp is less than the desired installation temperature (to), remove the closure rail at the centre and unfasten the full length of rails leaving only the anchor lengths at either end. Mount the rails on the rollers.
Note: Side rollers shall also be used while undertaking distressing on curved track. Side supports on the inside of curve should be spaced at every n^{th} sleeper,

$$\text{Where, } n = \frac{\text{Radius of curve (R)x No.of sleepers per rail length}}{50 \text{ x } (to - tp)}$$

Outside supports shall be used in addition at the rate of one for every three inside supports.
vi) Fix rail tensor across the gap at the centre and apply tension so as to get the required amount of extension as provided in Annexure –VII of L.W.R Manual.
vii) Re-fasten the rails starting from the anchor lengths at either end after removing the rollers progressively and adjusting tension at the rail tensor to make sure that the required extension has been achieved at each marker pillar.
viii) Put paint marks on either side of the gap at the centre, spanning over the gap at a distance of 6.5 metre. Insert a closure rail of a length equal to (6.5 metre - 2 gaps for welding + 1 mm for saw cut ends) and clamp
ix) Release and remove the rail tensor.
x) During another traffic block, weld both the joints of the closure rail at the centre.
xi) Equalize stress at the centre and at the anchor lengths.

Destressing of LWR/CWR on PSC sleeper track without use of rail tensors

1. A traffic block of adequate solution duration should be arranged at such time that the rail temperature will be within the temperature range specified for t_d during the following down operations. The entire work shall be done under personal supervision of PWI.
2. Before the block is actually taken a speed restriction of 30 km /h should be imposed and fastenings on alternate sleepers loosened.
3. When the block is taken the closure rails shall be removed the SEJ'S adjusted and fastened.
4. The remaining sleepers fastenings on both running rails shall be loosened or removed starting from the ends near the SEJ'S and proceeding towards the centre of LWR. The rail shall be lifted and placed on rollers at every 15^{th} sleeper to permit the rails to move freely.while distressing on curved track, provision of side rollers as per note of 5.7.2(v) of L.W.R manual may be adopted. The rails shall be struck horizontally with heavy wooden mallets to assist in their longitudinal movement.
5. The rollers shall than be removed the rails lowered to correct alignment and fastenings tightening, starting from the middle of LWR and

proceedings towards both end simultaneously. The tightening of fastenings shall be completed within the temperature range for t_d. The actual range of temperature during the period of tightening shall be recorded by PWI along with the time and date.

6. Simultaneously with the tightening of fastenings, arrangements for insertion of cut rails between the SEJ and LWR shall be started. The four gaps shall be measured individually and the rails of required length cut by saw keeping required gaps for At welding. The cut rails shall than be placed in position fastened to the sleepers and welded at each end. Fastenings for 20 metre on each end of the LWR shall be removed before welding joints shall be clamped for 20 minutes after welding.

Destressing of LWR/CWR on PSC sleeper track with use of rail tensors

The progress of destressing work is greatly handicapped because of the following two limitations

1. The destressing has to be done between specified range of temperature only
2. A long block of about 3 hours duration has to be arranged for distressing.

To overcome the above difficulties, Indian Railways have recently procured a few rail tensors either of hydraulic type called 'Hydro-Stressor' or of mechanical type called 'Mechanical Rail Tensor'.

A hydro stressor consists essentially of a hydraulic pump which transmits force through connecting vans to clamps, which grip the rail. In case of mechanical tensors the force is exerted mechanically by longitudinal jacks. By means of this force the rails can be pushed or pulled to a desired length. In case of pushing the force should not exceed 30 tons otherwise the track is likely to buckle on that account. The rails are however normally pulled only during the distressing operations. The rail tensor is capable of distressing a rail panel at any time, when the prevailing rail temperature is less than the distressing temperature.

Efforts are being made to develop non- infringing type jacks cam hydro stressors which will give advantage of allowing traffic on the track with tensor applied.

MAINTENANCE OF LWR/CWR

An important prerequisite for proper functioning of LWR/CWR is its initial laying to a high standard and its subsequent maintenance by trained personnel possessing valid competency certificates

REGULAR TRACK MAINTENANCE

Regular track maintenance in LWR/CWR includes following operations:-

a. Tamping/packing
b. Lifting
c. Aligning including minor realignment of curves
d. Shallow screening/shoulder cleaning
e. Renewal of fastenings requiring lifting
f. Maintenance of buffer rails

Summer Precautions –Maintenance of LWR/CWR/SWR

The precautions are of three types

1. General Precautions (General + Manual Maintenance)
2. Precautions while working with Tamping Machines
3. Precautions while working with Ballast Cleaning Machines

GENERAL PRECAUTIONS:

Knowledge of LWR manual

1. All the supervisory staff should have proper knowledge about the LWR manual
2. They should always keep a copy of LWR manual + correction slips issued time to time by office
3. They should ensure that all maintenance work is carried out as per the instructions and precautions as per LWR manual
4. Do's and Don'ts for LWR/CWR maintenance should be kept in mind
5. All supervisory staff's should be examined of their knowledge of LWR/CWR maintenance and their updating nature
6. The supervisory staff consists of the gang man, key man, PWI's etc.
7. The staff who poses adequate knowledge of LWR manual and having the competency certificate issued by the Zonal divisional training center are only posted on LWR/CWR sections
8. These certificates is valid for just 3 years from the date of issue

INSPECTION:

1. All CWR/LWR should be inspected at the peak temperature hour/day time by all levels of respective supervisors & officers to observe LWR/CWR behavior at highest temperatures
2. there should be no closure of track if exists a speed restriction of 30 kmph to be imposed and closure should be welded after distressing at recommended temperature range

BALLAST PROFILE:

1. Adequate ballast section to the standard profile should be ensured
2. Additional ballast should be arranged at the desired location asa per requirement

3. Ballast shoulders to be packed preferably
4. If immediate ballast arrangement is not possible then it can be arranged or managed by
    a. Crib ballast
    b. Pedestrian / Cattle crossing Ballast
    c. Cess Ballast etc
5. Areas of ballast disturbances such as pedestrian / cattle crossing etc can be protected by dwarf walls
6. Sufficient quantity of ballast shall be arranged in advance to maintenance work .

Reliability of Rail thermometer

1. The maintenance work should be carried out in specified temperature so reliability of thermometer is necessary
2. All the units should have the thermometer which are reliable
3. The temperature range for maintenance operation should be marked with green color on all the thermometers

Places of Special attention

1. SEJ's / Breathing length
2. Approaches of level crossing Points and crossings
3. Un ballasted desk bridges
4. Curves (Horizontal/Vertical)
5. Maintenance of fastenings (especially on concrete sleepers)
6. Fastenings shall be completed and well secured

Time for maintenance

Track structure consisting of other than concrete sleepers in LWR/CWR

1) The regular track maintenance in LWR/CWR shall be confined to hours when rail temperature is between t_d +10°C and td-30°C
2) It should be completed well before onset of summer.
3) If rail temperature after maintenance operation exceeds t_d + 20^0C during the period of consolidation, the speed restriction of 50 km/h on BG and 40 km/h on MG shall be imposed
4) when shoulder and crib compaction has been done and 30 km/h and 20 km/h respectively
5) when shoulder and crib compaction has not been done in addition to posting mobile watchman.

Track structure consisting of concrete sleepers :-

The regular track maintenance in LWR/CWR shall be confined to hours when the rail temperature is between t_d+10°C and t_d-30°C

It should be completed well before onset of summer.

If rail temperature after the maintenance operation exceeds t_d+20°C during the period of consolidation

then the speed restriction of 50 km/h on BG and 40 km/h on MG shall be imposed.

Manual maintenance

1. At a time not more than 30 sleepers spaces in a continuous stretch shall be opened for manual maintenance
2. If more sleepers are to be packed then a stretch of 30 sleepers are left/spaced between two sleeper stretches
3. If correction of alignment is to be done the shoulder ballast shall be opened out to the minimum extent necessary and that too, just opposite the sleeper end
4. The ballast in shoulders shall then be put back before opening out crib ballast for packing.
5. Maintenance in-between length shall not be under taken till 24 hrs of traffic passage. In case of BG carrying more than 10 GMT or 2 days in case of other BG tracks
6. It should be ensured that track is not kept open during lunch interval
7. If ballast section is disturbed for Maintenance then consolidation of crib and shoulder is must to restore lateral strength. The consolidation is done with wooden mallet/rammers as per prescribed ballast profile
8. Correction of alignment / slewing should be supervised by SE's/JE's (P.Way)
9. No lifting should be done if necessary that should be supervised by JE's /SE's P.way
10. For renewal of sleepers
    a. Not more than one sleeper in 30 consecutive sleepers shall be replaced at a time.
    b. If necessary to renew two or more consecutive sleepers in the same length, they may be renewed one at a time after packing the sleepers renewed earlier duly observing the temperature limits specified together with precautions Specified.

Renewal of fastenings

1. Replacement/Renewal should be done at t_d+10°C or below and zero missing should be achieved before Maintenance
2. Replacement of rubber pads should not be done in summer because lifting of rail is required for this and kinks may be formed in the rail.

Note: the Maintenance work should be stopped immediately as soon as rail temperature reaches t_d+10°C.

Mechanized Maintenance

Tie tamping machine maintenance

All the steps of general maintenance should be carried out except manual maintenance

Working Hours:

1) Block should be availed when rail temperature is below t_d +10°C
2) Machine should not work after t_d +10°C
3) Normally night (or) early morning block is taken during summer.

Regarding Lift

1. lift allowed in case of concrete sleeper is 50 mm

2. lift allowed in case of other sleeper is 25 mm
3. If lift more than that is required then it is carried out in steps. After ensuring the consolidation of previous stages

Speed Restriction:

1. As the temperature reaches above t_d+20 ^{0}C after machine maintenance then a speed restriction of 50 kmph in BG and 40 kmph in MG is imposed till consolidation period
2. No speed restriction is required as if the machine is followed by DTS machine (or) Dynamic stabilization is done

Deep Screening / Maintenance with BCM Machines

LWR is cut into SWR for carrying out deep screening in summer this may cause the increase of weld population and locking up of stress increases so this has to be avoided

Restriction based on Degree

1. No deep screening is to be done on following conditions
    i. Beyond t_d+10^{o}C in straight curve upto 3^o
    ii. Beyond t_d+5^{o}C in curves sharper than 3^o
2. Deep screening of SWR is utilized for the above condition
3. Deep Screening of point and crossing is utilized at t_d+10^{o}C

Suspension of Deep Screening:

1. When rail temperature reaches or exceeds t_d+15^{o}C in any part of day no deep screening is carried out
2. Normally from march end to june end every year
3. Deep screening is taken to hand till temperature falls below t_d+15^{o}C

SPECIAL EQUIPMENT FOR MAINTENANCE OF LWR/CWR

Staff responsible for maintenance of LWR/CWR shall be trained in using and equipped with additional equipment detailed below:-

Additional equipment with the Gangs

i. A pair of joggled fishplates with bolted clamps
ii. Rail thermometer with markings for temperature ranges for maintenance
iii. Special 1 metre long fishplates with screw clamps
iv. Rail closure pieces.

UNUSUAL OCCURRENCES

Unusual occurrences in LWR/CWR comprise of the following:-

i) Rail fractures or replacement of defective rail/ glued joint
ii) Damage to SEJ/buffer rails
iii) Buckling or tendency towards buckling
iv) Factors causing disturbance to LWR/CWR such as accidents, breaches etc.

BUCKLING OF TRACK

Buckling or a tendency towards buckling may occur, among others, in the following circumstances:-

i. Failure to adhere to the temperature ranges specified for operation on LWR/CWR
ii. Inadequate resistance to longitudinal, lateral and vertical movement of track due to deficiencies in ballast section or/and inadequate ballast consolidation
iii. Use of ineffective fastenings or missing fastenings resulting in loss of creep resistance and torsional resistance
iv. Excessive settlement of formation
v. Improper functioning of SEJ.

Hot Weather Patrolling

1. It is introduced rises above t_d+20 ^{0}C or t_d+25 ^{0}C
2. If temperature is in rising mode than patrolling may be introduced before t_d+20 ^{0}C or t_d+25 ^{0}C
3. All preliminary arrangement for patrolling including selection and counseling of patrolmen should be kept ready
4. PWM/PWI of units/gangs be advised to commence patrolling of their own discretion as per LWR manual.

REGULAR TRACK MAINTENANCE

Regular Track Maintenance

Old Traditional System
(Manual System)

Modern Method
(Mechanical Maintenance System)

3 Tier System

1. Maintenance of track by track machine
2. Maintenance of track by mobile Maintenance unit (MMU)
3. Rest maintenance carried out by sectional gang

Note: MMU is a combination of road cum rail vehicle

Manual Maintenance (Traditional method)

S.No	`Process	Duration	Properties Maintained	IF m/C used Which M/C
1	Through Packing	Once in a year	Track health and track parameters	TTM(Tie Tamping Machines)
2	Overhauling	Once in 4/3 Years	Shoulder , Crib ballast Screening	FRM, SBCM
3	Deep Screening	Once in 10 to 12 years	Entire Ballast Section is screened with 1": Square mesh	BCM
4	Pick up The Slacks	As per Need	Un wanted material are removed from track	
5	Special Work	As per Need	Renewal of track, Rails, Fasteners, ballast regulation, Lubrication of fittings and fastenings etc	BRM,T-28,PQRS, SQRS ,ATRT,RTRT etc

Note :

Normally all the process are not complete without through packing. In case of Deep Screening 7 Rounds of through Packing +21 days of speed restriction is provided on the track in case of Manual maintenance. In case of Machine Maintenance it is 10 days.

Through Packing :

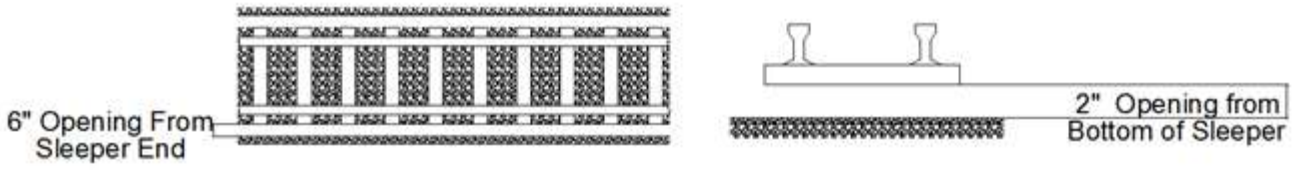
Through packing consists of the following operations in sequence. The length of track opened out on any one day shall not be more than that can be efficiently tackled before the end of the day:

1. Opening of track.
2. Examination of rails, sleepers and fastenings
3. Squaring and spacing of sleepers.
4. Slewing of track to correct alignment.
5. Gauging.
6. Packing of sleepers.
7. Repacking of joint sleepers.
8. Boxing and tyding.

The sectional gang start in working season the work of through packing from one end of gang beat and goes to another end till completion of the work in that section

Opening of Track :

Opening of ballast is carried out in both ends of sleeper up to 6" away and crib ballast under the rail seat up to minimum depth of 2" from the bottom of the sleeper by the claw

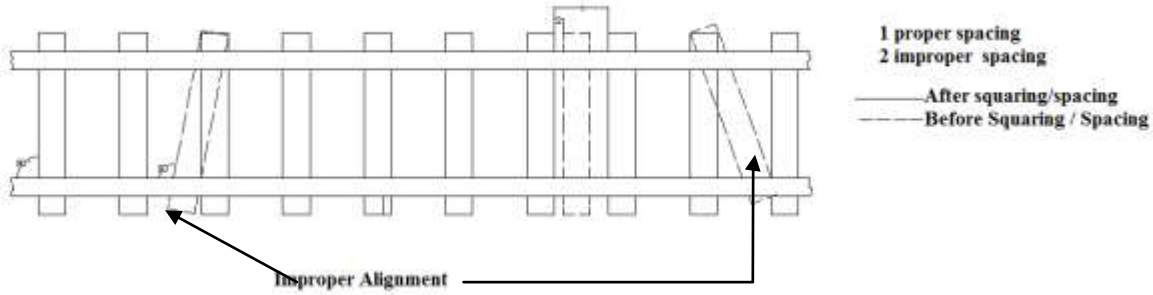


Examination of Rails, Sleepers and Fastenings –

Operation of this sequence track health is made strong. Worn-out/ Unserviceable sleepers are replaced by serviceable sleepers, missing fitting and fasteners/unserviceable fitting and fastenings are replaced by new one

Spacing and Squaring of sleepers: -

In this sequence after the replacement of Worn-out/Unserviceable components of track. The sleepers are spaced and squared as per requirement. This is necessary for smooth /Good/Efficient running of the train.



Slewing of track to correct alignment:

In this sequence of operation the gang mate collects workmen at one place and select one rail as reference rail. This reference rail is aligned manually with crow bar and in the eye view standing 3 rail behind from the aligned position.

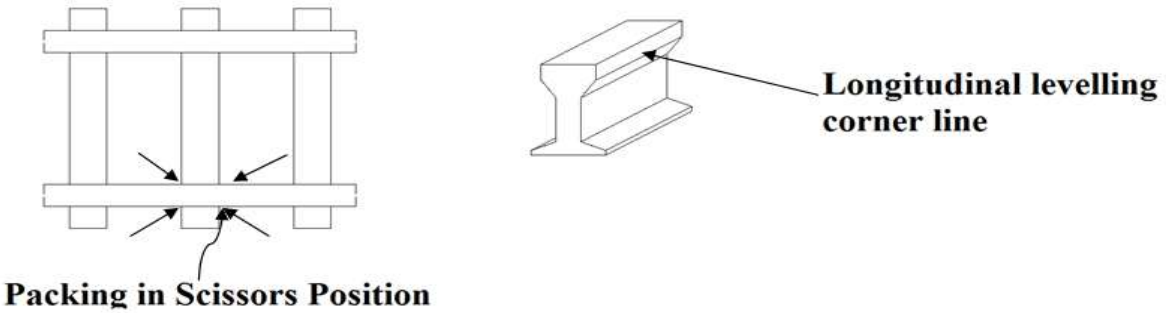
Gauging:-

After the alignment gauging to the track is corrected in second rail(other than reference rail) Normally this gauging is also carried out in eye view to avoid kinks etc. No sudden change in the gauge is allowed even tolerance is permitted. After the correction the gauge correctness is checked by the gang mate with the help of track gauge measuring instrument.

Packing of sleepers

In this sequence longitudinal and cross level of the track is corrected by lifting of the track and packing of the sleepers. The work of longitudinal leveling is supervised by the gang mate in eye view from one rail behind and looking reference rail cutter face bottom corners.

After the leveling of the reference rail, second rail is also lifted and packed in zero cross level in same fashion as reference rail is packed. After the leveling each pair of gang men return in the sleeper bit and well packed in scissor's position



Repacking of joint sleepers:

After coming back from the lunch gang mate examines the deficiency of the track generated by moving train during the period of the lunch. Such locations are identified by the mate and repacked /realigned as per need to correct alignment and leveling of track . After this each pair again packed each sleepers as a final packing and joint sleepers are specially repacked

Boxing and Tyding: –

After final packing of the track the opened ballast repositioned in the track with the help of claw and sleepers are fully boxed as per standard ballast profile of the track. Ballast deficiency are re-equipped and excess ballast are removed and collected to the cess. All the green dries are removed from the track , drains are repaired, cleared and trolley refuges are required..

Over Hauling of Track:-

Overhauling of the track is done for the following purpose

1. To improve the drainage
2. To make availability of the clean ballast for packing

In this process shoulder ballast and crib ballast up to 4" from the bottom of sleepers screened by 25mm manually. Since no cushion ballast is disturbed hence no caution is required for carrying out the process. After the screening all eight operations of the through packing is essential to carry out in the track then only overhauling operation will be treated complete

Normally one fourth section of the gang bit is overhauled every year but the location around the sub-urban areas and other track circulated zone. Where chance of dirty ballast is more overhauling can be carried out in every three years.

Deep Screening

In this operation entire ballast section is cleaned by 25mm mesh manually. Since in this operation cushion ballast bed is disturbed. Hence the operation is carried out by supporting track on wooden block under the 15 kmph(20 kmph caution). This caution is rest after six round of through packing and intermediate stabilization period gradually from (20-30-50-70) to normal about 21 days are involved in this operation.

Various restrictions applied immediately after the work

After Manual Packing

1. Pre-Stressed concrete sleepers – 20 kmph
2. Other stressed - 10 kmph

After BCM working (only on PRC)

1. BCM - 20 kmph
2. BCM+TTM – 30 kmph
3. BCM+TTM+DGS – 40 kmph

Note :

Normally 15kmph should be implemented on the track after imdetiade end of the packing / Screening. Since nowadays the implementation of speed is not in multiplies of 5 for slower speed so it is implemented in the multiplies of 10.

Picking up of Slacks

Basically it is the need based maintenance. Which is carried out in the track in non-working seasons(in monsoons etc) when through packing and other maintenance work could not be carried out . in this operation only the affected portion of the track(settles track) is attended to maintain the certain maintenance standard of the track. So that safe running of the train can be assured.

The location of defect is identified by the track recording car (TRC) restart trolley in section, foot plot inspection and foot inspection only.

Normally in this operation following locations are attended regularly.

i) SEJ, Glued Joints and fish plated joint.
ii) Approaches of the girder bridges, Level crossings and points & Crossing
iii) Weak formation
iv) Pedestal and cattle crossing
v) Breathing length of LWR
vi) Location Where ballast is dirty etc .

Precautions to be taken while Working in Track circuited Areas-

1. The Permanent way inspector should instruct the staff not to place across or touching two rails in the track any tool or metal object which may cause sort circuiting.
2. All gauges, levels, trollys and lorries used on the track circuited length should be insulated.
3. Steel or C.I. pipes used for carrying water/ gas under the track should be run sufficiently below the rails to prevent any short circuiting.
4. While carrying out track maintenance, care should be taken to see that no damage of track circuit fittings like rail bonding wires, lead wires to rails, boot leg, jumper wires etc., takes place.
5. Use of steel tapes should be avoided in track circuited section.
6. Pulling back of rails should be done in track circuited areas in the presence of S&T staff, where signaling connections are involved.
7. Proper drainage should be ensured so as to avoid flooding of track, during rains, particularly in yards, where watering of coaches is done and in water columns and ash pits. It would be desirable to provide washable concrete aprons on platform lines at originating stations, in track circuited areas.
8. Ballast must be kept clean throughout the track circuited section and care should be taken to see that the ballast is kept clear of the rails and rail fastenings. The clearance from the foot of the rail should not be less than 50mm. During every packing this point should be taken note of.

Precautions to be taken while Working in Track circuited Areas are

1. Incharge Sectional P. Way Engineer shall instruct the staff not to place across or touching two rails in the track, any tool or metal object which may cause short circuiting.
2. All gauges, levels, trolleys and lorries used on the track circuited length shall be insulated.
3. Steel or C. 1 pipes used for carrying water gas under the track shall be placed sufficiently below the rails to prevent any short circuiting.
4. While carrying out track maintenance, care shall be taken to ensure that no damage of track circuit fittings like bond wires bootlegs, jumped wires
5. Use of steel tape should be avoided.
6. Pulling back of rails in track circuited areas shall be done in the presence of S&T staff.
7. Proper drainage shall be ensured in yard to avoid flooding of track during rains., where watering of coaches is done. It would be desirable to provide washable concrete aprons on platform lines.
8. Ballast shall be kept clean through out the track circuited length and care shall be taken to ensure that ballast is kept clear of rails i.e. 50mm from under side the foot of rail.
9. Min. ballast resistance per Km. of track < 20 ohms in the station yards and < 4 ohms in block sections.

Maintenance in Electrified Areas

General Instructions to staff –

(1) General Knowledge of Engineering Staff-

(a) Every engineering official working in electrical traction area shall be in possession of a copy of rules framed for the purpose of the operation of the Traction Power Distribution system pertaining to Engineering Department and ensure that staff working under him are also acquainted with the rules. He will ensure that rules pertaining to carrying out engineering works are strictly observed.

(b) All electrical equipment, every power line or cable shall be regarded as being 'live' at all times. No work shall be commenced adjacent to any electrical equipment except on authority issued in writing by a competent official of the Electrical Department to the effect that the equipment has been made dead and earthed.

(2) Defects in a Overhead Equipment:-Defects or break-downs in the overhead equipment including track and structure bonds noticed by the Engineering staff shall be reported immediately to the Traction Power Controller. When defects in the overhead equipment that are likely to cause damage to pantographs or trains, are noticed and it is not possible to convey information to Station Masters or signalmen to enable them to issue caution orders, the line shall be protected by the staff noticing such defects according to General Rule 3.62.

(3) Traction Bonds - In electrified areas the return current fully or partially flows through the rail. To ensure a reliable electrical circuit continuity and also to ensure proper earthing in case of leakage of current, various types of traction bonds as described below are provided at suitable places and maintained by the Electrical Traction Department.

(a) Longitudinal Rail Bonds - In the case of D.C. traction system, practically the whole return current flows through the rail. Therefore, two flexible copper bonds offering minimum resistance to the flow of current are provided at each rail joint under the fish-plates. Two solid lugs at the two ends of the copper bonds are inserted in holes drilled at the two rail ends between the fish bolt holes and are pressed by using a bend press to rivet them firmly to the rail. On points and crossings and at junction fish-plates where continuity bonds of the above type can not be provided due to space constraint, continuity of return current path is achieved by using mild steel straps or G.I. wire ropes. Absence of such bonds may cause unsafe working condition and in extreme cases may damage the rail ends.

(b) Cross Bonds (D.C.) :- Cross bonds are provided between adjacent tracks at regular intervals to reduce resistance of the current to the minimum. Such

cross bonds are also known as transverse bonds.

(c) Structure Bonds .-All structures supporting overhead equipment either in A.C or D.C. track circuited areas are connected to the running rails for ensuring good earthling. Failure of insulator or leakage of current switches off the supply from the sub-station so that men coming in contact with supporting structure etc. do not get electric shock. Removal or tampering of such bonds can, therefore, result in unsafe conditions. Since the structures are grouted in concrete, they are likely to become charged in case such bonds are kept disconnected. Similarly other steel structures such as foot-over bridges, sheds, etc., in the vicinity of O.H.E. lines are also connected to rails through similar structure bonds.

PERMANENT WAY RENEWALS

Necessity For track renewal

- ⇒ When track materials are wornout
- ⇒ When track structure is reqired to change for increasing axle load of the section
- ⇒ When the MSS of the section is required to be increased
- ⇒ When serviceable materials of the main line is required for renewal of the branch line .

Classification of Renewals - All track renewals can be classified generally into one of the following categories :

1. Complete Track Renewal C.T.R
2. Through Rail Renewal T.R.R
3. Through Sleeper Renewal T.S.R.
4. Through Turn-out renewal (TTR)
5. Through Fitting & Fastening renewal (TFR)
6. Through Weld renewal (TWR)
7. Through Bridge timber renewal (TBTR)
8. Through Ballast Renewal (TBR)

Casual Renewals.: It is not the part of Regular Track Maintenance

Scattered renewal :It is the part of Regular Track Maintenance

Casual Renewal-

In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage or new track components.

These are carried out in isolated locations of continuous but small stretches. Such renewals are not a part of normal maintenance operations and cannot be covered under scattered renewals.

Scattered Renewal

In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage track components.

These are carried out in isolated locations and not more than 10 rails and/or 250 sleepers in a gang beat in a year. Such renewals are a part of normal maintenance operations.

Types of Renewal on the basis of materials used

1. Primary Renewal
2. Secondary Renewal
3. Tertiary Renewal

Primary renewals

Primary renewals are those where only new materials are used for renewal. Normally it is done on main line

Secondary renewals

Secondary renewals are those where released serviceable materials are used. Normally it is done on branch line

Tertiary renewals

Tertiary renewals are those where released serviceable materials from branch line are used. Normally it is done on Yards.

When we do Renewal

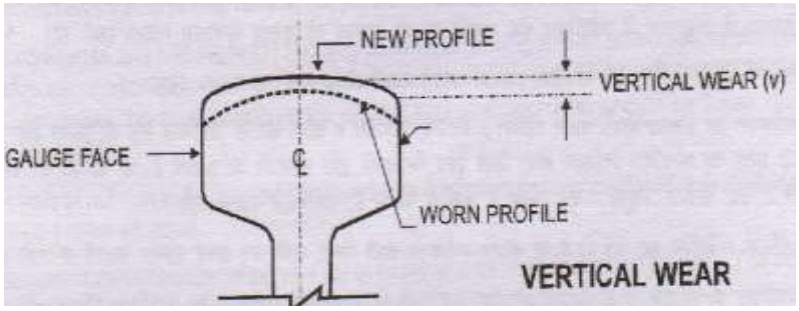
Safety Consideration : when it is difficult to maintain the track with safety

Economic Consideration: When the maintenance cost of track becomes very high we go for renewals

On basis of Rail Fracture : when the rail fracture of the section beyond limit and on basis of USFD (Ultrasonic Flaw detection Test) Testing results we take decision of rail renewals.

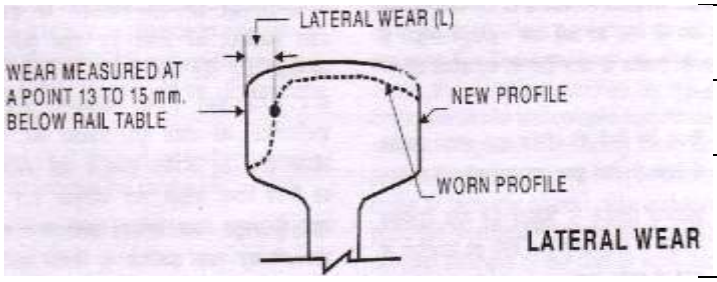
Due to Wear :

Vertical Wear



Rail Section	Vertical Wear in mm
60 KG	13
52 KG	8
90 R	6

Lateral Wear



Route	Straight Track	Curved Track
A , B	6 mm	8 mm
C , D	5 mm	10 mm

Percentage Loss in Weight

Gauge	Rail Section	Loss in Section in percentage
B. G	52 Kg. / metre	6
	90 R ...	5
M.G.....	75 R....	4.2
	60 R...	3.25

Till weight loss percentage for 6o kg rail has to been desired

Due to Corrosion

When the thickness of web reduced to more than 1.5 mm

On Basis of Service life

Gauge	Rail Section	Total G.M.T. carried for T.12 Med. Manganese rails	Total GMT carried for 90 UTS rails
B. G.	60 kg/m	550	800
	52kg/m	350	525
	90 R	250	375
M. G.	75 R	150	.
	60R	125	.

Note : On major bridges and on all important bridges where height of bank is 4metre or more and on tunnel approaches . upto 100 meter either side of bridge/tunnel and on bridge. The track will be renewed after passing the half of the stipulated GMT.

Planned Way Renewal

Such renewal are part of major planning and it may be premature renewals

This type of renewals are carried out when we need track modernization speed to increase and gauge renewals etc.

Sleeper renewal :

a. When sleeper are failed to retain gauges and packings they should be renewed
b. Wooden Sleepers : when 30% sleepers are damaged due to broken, wear out, then TSR shall be done
c. Steel sleepers shall be done when they are broken, wornout etc .

Method of Renewal :

1. Manual method
2. Machined Method
    a. PQRS
    b. TRT
    c. T-28

Track Tolerance

Safety and comfort by depends upon the 'track geometry. Which further depends upon the 'laying and maintenance'. Standard of track. It is never possible to lay and maintain a track without error and also it is not necessary. The level of maintenances of track as up-down (variations) as per head. For example on rajdhani routes, high class maintenance level is required while on branch line it is neither required nor possible because of 'Low –Traffic' and 'Costly affair'. Hence some relaxation is given in pertaining parameters for persons who are working on the track for their guide lines. This relaxation is known as track Tolerance.

The limited variations of track parameters which are acceptable in sense of safety and comfort is known as track tolerance.

Track Parameter

Gauge: vertical distance between two gauge faces of track (rail) is known as gauge
Un-Evenness: The difference of level of both (two) rails is measured separately on a fixed base is known as unevenness of track.
On BG it is measured by 3.6 meter chord
Twist : Rate change of X level is known as twist. It is measured on 3.5 meter base and it is denoted as mm/meter
Cross Level: Difference of level of both rails (measured vertically) is known as X-Level

Alignment of track is measured separately for left and right rail. It is measured at 7.5 meter base but on Rajthani Route ('A' route) this is measured on 10 meter base.

Alignment is normally checked by Eye-Focus standing by 25 mtr behind from location(But Normally it is checked from distance behind three rails)
Tolerances under Loaded/ Floating Condition:

The gauge and alignment is normally not affected under the loaded condition but evenness. Cross level and twist is affected much more and its variations under load have a great importance. Difference countries of world have studied but most effective results are given by Japanese National railways which are as under

S.no	Parameters	Value under Condition Of	
		Load	Floating
1	Longitudinal Level	10 mm	6 mm
2	Cross level	12mm	6 mm
3	Gauge	G +(1 to 1.5 mm)	G mm
4	Alignment	A	A +(1 to 1.5 mm)

Note : it is impossible to maintain the track parameter are same in both conditions.

Type of tolerance

1. Safety Tolerance
2. Service Tolerance
3. Maintenance Tolerance
4. Index Tolerance
5. Track Tolerance

Safety Tolerance

This is the tolerance which is assumed to cross its limits. There are chances of derailment and running of the train is quite unsafe. These tolerance are suspicious and doubt full till date. Hence no railway still decided the limit of the safety tolerance in the world.

Service Tolerance :

This is the tolerance in which parameters can be increased or Decreased during the course of service. This Tolerance depends up on the type of vehicle and acceptable riding comfort the passangers.
The limit of service tolerance is prescribed with is as under and we have to start our maintanence work well before reaching to limit

For High Speed Route

S.no	Parameter	Normal/Busy Track	Isolated Track
1	Gauge a. Straight b. Curve upto 4 ° c. Curve Sharper than 4°	 -3 to + 6mm -3 to + 13 mm Upto +19mm	 -3 to + 6mm -3 to + 13 mm Upto +19mm
2	Unevenness under loaded condition measured on 3.5 m chord	6mm	10 mm
3	Cross Level: Under service tolerance no limit is still decided for cross level in IR. But level of maintenance should be as such extend so that train can pass without restricted speed	-	-
4	Twist under loaded condition 1. Straight & Curved track except transition portion 2. On transition Portion	 2mm/m 1mm/m	 3.5mm/m 2 mm/m
5	Alignment: Alignment measured as versine on 7.5 m chord (on trunk route with 10 m chord) a. Straight b. Curve	 ±5mm ±5mm	 ±10mm ±7mm
Note: maximum permitted station to station change in versine is ±10mm			

Maintanence Tolerance:

These are the tolerance which is achieved twist after the maintenance operation. This depends upon the track structure quality of tools / machines type of maintenance and standard of the supervision. The limit of maintenance tolerance is fixed to achieve certain.

In Indian railways limit of the maintenance tolerance is not fixed rigidly anywhere. But Northern railway has given direction in this field.

Under floating condition which is normally acceptable to all the results after the track maintenance with heavy track tamper will be as below.

a) Unevenness (Based on 3.5 m chord)	±2mm
b) Alignment (Based on 7.5 m chord)	±2mm
c) Cross level	±2mm

There is tolerance which indicates the start of maintenance work as soon as will touch its limit.

Index Tolerance:

The limit of index tolerance is slightly lower. The limit of the service tolerance. The Northern railway has given directives in this regard for 'A' category Routes are as under

a) Cross level
b) Alignment (measured on 7.5m chord base)
c) No 2 consecutive sleepers to be loose and joint sleeper to be loosen
d) Sleeper to sleeper gauge variations = 1 mm

New Track Tolerance :

The tolerance that are achieved just after the track laying or CTR

S.no	Parameter/Factors	Tolerance
1	Track Recording Car (TRC)	'A'
2.	Oscillation Monitoring System (OMS)	Peek not exceed more than 0.15G
3.	Track Gauge: i. Straight gauge (Radius more than 350m) ii. Radius < 350m Sleeper to sleeper gauge variation should not be 2mm	 - 5mm to +3mm Upto 10mm slack
4	Cross level Note: measured on every 4th sleeper	 ±3mm
5	Alignment measured on 10 m station i. Straight ii. Curved track radius up to 600m iii. Curved track radius below 600m	 ±2mm ±10mm ±5mm

Schedule of Dimensions:

Present Schedule of Dimensions:

The present SOD revised in the year 2004 consist all the dimensions in metric units. All the dimensions in FPS units have been deleted. The following modifications have been done in the SOD of 1973:

Schedules:

Revised SOD of year 2004 contains only two schedule

i. **Schedule-1**
ii. **Schedule-II.**

Schedule-I:

Consists of those items which are mandatory and have to be observed on all 1676mm gauge on Railways in India. This also contains certain selected items of schedule-II of 1973 version of SOD. In this schedule, dimensions have been classified under two heads namely for "Existing works" i.e. the works existing before the issue of new SOD year 2004 and for "New works" which would include new constructions, additions of new lines/structure, gauge conversion and doubling except the alterations to points & crossing siding, building etc. Any deviations to the dimension of new works will require prior sanction of CCRS/CRS.

Schedule-II:

Consists of items included in Schedule-III of 1973 version of SOD.

In addition to above the appendix dealing with extra clearances required on curves have been modified to suit maximum speed of 160 Kmph and maximum SE of 165mm as per high speed, Rajdhani and Shatabdi routes with other parameters kept as earlier. Correction slips issued from time to time to SOD of 1973 have been incorporated in revised SOD of year 2004.

Chapter Wise Details of Contents in Schedule of Dimensions:

Chapter		Schedule	Details of Contents
I	General	1	Spacing of tracks curves bridge, rails, building and structures, interlocking and signal gears tunnels, through semi through girder bridges and safety refuges formation width gauge on straight and curves.
II	Station Yards	1	Spacing of tracks, platforms, buildings & structures, points and crossings, length of sidings.
III	Workshop & Station machinery	1	Water tanks and Water Cranes, workshops and running sheds.
IV(A)	Rolling stock (C&W)	1	Wheel and axles, height of floors, buffers & couplings wheel base & axles base and length of vehicles, max moving dimensions, loading gauge

			for goods
IV(B)	Rolling stock (3660mm wide stock)	1	Maximum future moving dimensions, loading gauge for goods.
IV(C)	Rolling Stock (Locomotives)	1	Wheels and axles, buffer & couplings, max. moving dimensions, max. moving dimension for Locomotives.
V	Electric traction (DC)	1	
V(A)	Electric traction 25KV AC 50 Cycles	1	Electrical Clearances
	AC 50 Cycles Schedule	II	Existing infringements of schedule 1 which may be permitted to continue on 167mm gauge railways.

Loading Gauge:

Loading gauge represents the maximum width and height to which a rolling stock viz, Locomotive, Coach or Wagon may be built or loaded.
On Indian Railways maximum height and width of rolling stock prescribed as per loading gauge is as follows-

Maximum Height 4565mm
Maximum Width 3250mm

Construction gauge is decided by adding necessary clearance to the loading gauge so that vehicles can move safely at prescribed speed without any infringements. Various fixed structures on the railways like bridges; tunnel and platform sheds etc. are built as per construction gauge so that the sides and top remain clear of the loading gauge.

Standard Moving Dimensions:

Construction of rolling stock (Loco, carriage and wagon) and movement of conventional rolling stock is based on certain standard moving dimensions provided in the SOD. Sometimes very large consignments which when loaded on ordinary or special wagons exceed the standard moving dimensions, their transportation development of industries in a region etc.

Indian Railways have evolved a standard procedure to enable quick movement of such consignments with certain restrictions regarding day or night movement, speeds loading, lashing & packing conditions depending upon the minimum clearance available to fixed structures on the routes required to be traversed. Such consignments are called “Out of Gauge” or Over Dimension Consignments.

Over Dimensioned Consignment (ODC):

When a consignment whose length, width and height is such that one or more of them infringe the standard moving dimension at any point during the run, then the consignment is called as Over Dimensioned Consignment (ODC). The movement of ODC has been standardized on Indian Railways and each zonal railway keeps the upto date list of infringements.

In case of loaded consignment extra clearance of 75mm for bounce in the vertical direction on a straight track shall be accounted for between consignment & fixed structure. But in case of curved track the following additional factors shall be taken into account.

1. Horizontal Clearance	Allowance for lean due to super elevation and overhead due to curvatures additional lurch on curves.
2. Vertical Clearance	Vertical tilt to be added to the height of consignment.

Classification of ODCs:

Taking into account of extra clearance as indicated above, oversized consignments are classified into following three classes –

Class 'A' – Permitted out of gauge loads or O.D.C.

1. It runs with the permission of chief operating manager
2. It runs in both day and night
3. It runs with maximum speed of 75mm kmph
4. It as gross clearance of 225 mm and above
5. It runs on the supervision of guard

Class 'B' – Exceptional out of gauge loads or ODC.

1. It runs with the permission of Dy.chief Engineer (civil) only.
2. It runs in both day and night
3. It runs with maximum speed of 40 kmph. But in yard it will run in 8 kmph
4. It as gross clearance of 150 mm only
5. It runs on the supervision of Traffic inspector (TI), TXR, Section Engineer(Carriage and Wagon) etc

Class 'C' – Extra-orinary out of gauge loads or ODC

1. It runs with the permission of CRS only.
2. It runs in day only
3. It runs with maximum speed of 25 kmph. But in yard it will run in 8 kmph
4. It as gross clearance less than 150 mm and not less than 75 mm.
5. It runs on the supervision of Traffic inspector (TI), TXR, PWI, Guard and OHE staff etc.