INTRODUCTION

Definition:

Railway engineering is a multi-faceted engineering discipline dealing with the design, construction and operation of all types of rail transport systems.

Advantages of Railways:

Economical aspects:

- Due to railways, the industrial development in for off places is possible, increasing the land values & standard of living of the people.
- Mobility of labour has contributed to industrial development.
- During famines, railways have played the vital role in transporting food & clothing to the affected areas.
- Commercial farming is very much helped by the railway network throughout the country.
- Speed movement of the commodities is possible through railways.

Cultural & Social aspects:

- Railway has made it easier to reach places of religious importance.
- Railway provides a convenient & safe mode of transport through out the country.
- During travel as people of different caste & religions sit together the interaction is developed.

Political aspects:

- Railways have helped in the mass migration of the population.
- Railways have created the sense of unity among the people of different religions, areas, castes & traditions.
- With adequate network of railways, the central administration has become easy & effective.

PERMANENT WAY

Definition:

A permanent way or a railway track can be defined as the combination of rails, fitted on sleepers and resting on ballast and sub grade.

Components of a Railway Track:

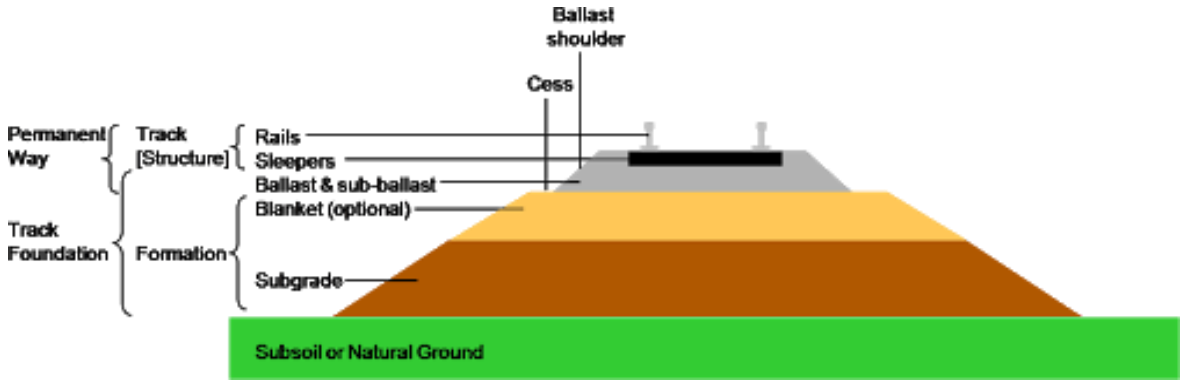
The Typical components are: 1. Rails

2. Sleepers (or ties)

3. Fasteners

4. Ballast (or slab track)

5. Sub grade



The rails are joined in series by fish plates and bolts & they are fixed to sleepers by different types of fastenings. The sleepers properly spaced, resting on ballast are suitably packed and boxed with ballast. The layer of ballast rests on the prepared sub grade is called as the formation.

The rails transmit the wheel load to the sleepers. The sleepers hold the rails in proper position and transmit the load from rails to ballast. The ballast distributes the load over the formation and holds the sleepers in position.

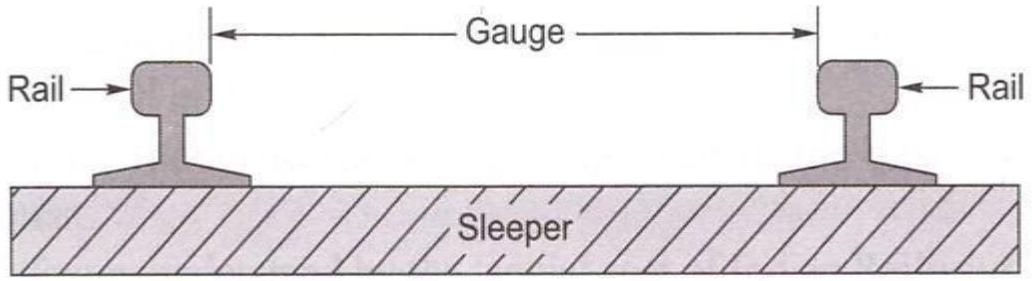
On curved tracks, super elevation is maintained by ballast and the formation is leveled. Minimum ballast cushion is maintained at inner rail, while the outer rail gets kept more ballast cushion. Additional quantity of ballast is provided on the outer cess of each track for which the base width of the ballast is kept more than for a straight track.

Requirements of an ideal permanent way:

- The gauge should be uniform and correct.
- Both the rails should be at the same level in a straight track.
- On curves proper super elevation should be provided to the outer rail.
- The permanent way should be properly designed so that the load of the train is uniformly distributed over the two rails.
- The track should have enough lateral strength.
- The radii and super elevation, provided on curves, should be properly designed.
- The track must have certain amount of elasticity
- All joints, points and crossings should be properly designed.
- Drainage system of permanent way should be perfect.
- All the components of permanent way should satisfy the design requirements.
- It should have adequate provision for easy renewals and repairs.

Gauge:

The clear minimum horizontal distance between the inner (running) faces of the two rails forming a track is known as Gauge. Indian railway followed this practice. In European countries, the gauge is measured between the inner faces of two rails at a point 14 mm below the top of the rail.



Various Gauges in Indian Railways:

Name of Gauge	Width(m)
Broad gauge(BG)	1.676
Meter gauge(MG)	1.00
Narrow gauge(NG)	0.762
	0.61

1. Broad Gauge: -

When the clear horizontal distance between the inner faces of two parallel rails forming a track is 1676mm the gauge is called Broad Gauge (B.G) This gauge is also known as standard gauge of India and is the broadest gauge of the world. 50% India's railway tracks have been laid to this gauge.

Suitability: Broad gauge is suitable under the following Conditions:-

(i) When sufficient funds are available for the railway project.
(ii) When the prospects of revenue are very bright.

This gauge is, therefore, used for tracks in plain areas which are densely populated i.e. for routes of maximum traffic, intensities and at places which are centres of industry and commerce.

2. Metre Gauge: -

When the clear horizontal distance between the inner faces of two parallel rails forming a track is 1000mm, the gauge is known as Metre Gauge (M.G). 40% of India's railway tracks have been laid to this gauge.

Suitability: Metre Gauge is suitable under the following conditions:-

(i) When the funds available for the railway project are inadequate.
(ii) When the prospects of revenue are not very bright.

This gauge is, therefore, used for tracks in under-developed areas and in interior areas, where traffic intensity is small and prospects for future development are not very bright.

3. Narrow Gauge:-

When the clear horizontal distance between the inner faces of two parallel rails forming a track is either 762mm or 610mm, the gauge is known as Narrow gauge (N.G) .10% of India's railway tracks have been laid to this gauge.

Suitability: Narrow gauge is suitable under the following conditions:-

(i) When the construction of a track with wider gauge is prohibited due to the provision of sharp curves, steep gradients, narrow bridges and tunnels etc.
(ii) When the prospects of revenue are not very bright.

This gauge is, therefore, used in hilly and very thinly populated areas. The feeder gauge is commonly used for feeding raw materials to big government manufacturing concerns as well as to private factories such as steel plants, oil refineries, sugar factories, etc.

Choice of Gauge:

The choice of gauge is very limited, as each country has a fixed gauge and all new railway lines are constructed to adhere to the standard gauge. However, the following factors theoretically influence the choice of the gauge:

Cost considerations:

There is only a marginal increase in the cost of the track if a wider gauge is adopted. In this connection, the following points are important:

(a) There is a proportional increase in the cost of acquisition of land, earthwork, rails, sleepers, ballast, and other track items when constructing a wider gauge.

(b) The cost of building bridges, culverts, and runnels increases only marginally due to a wider gauge.

(c) The cost of constructing station buildings, platforms, staff quarters, level crossings, signals, etc., associated with the railway network is more or less the same for all gauges.

(d) The cost of rolling stock is independent of the gauge of the track for carrying the same volume of traffic.

Traffic considerations:

The volume of traffic depends upon the size of wagons and the speed and hauling capacity of the train. Thus, the following points need to be considered:

(a) As a wider gauge can carry larger wagons and coaches, it can theoretically carry more traffic.

(b) A wider gauge has a greater potential at higher speeds, because speed is a function of the diameter of the wheel, which in turn is limited by the width of the gauge. As a thumb rule, diameter of the wheel is kept 75 per cent of gauge width.

(c) The type of traction and signalling equipment required are independent of the gauge.

Physical features of the country:

It is possible to adopt steeper gradients and sharper curves for a narrow gauge as compared to a wider gauge.

Uniformity of gauge:

The existence of a uniform gauge in a country enables smooth, speedy, and efficient operation of trains. Therefore, a single gauge should be adopted irrespective of the minor advantages of a wider gauge and the few limitations of a narrower gauge.

RAILS

Definition:

Rails are the members of the track laid in two parallel lines to provide an unchanging, continuous, and level surface for the movement of trains. To be able to withstand stresses, they are made of high-carbon steel.

Functions of Rails:

Rails are similar to steel girders. They perform the following functions in a track:

- Rails provide a continuous and level surface for the movement of trains.
- They provide a pathway which is smooth and has very little friction. The friction between the steel wheel and the steel rail is about one-fifth of the friction between the pneumatic tyre and a metalled road.
- They serve as a lateral guide for the wheels.
- They bear the stresses developed due to vertical loads transmitted to them through axles and wheels of rolling stock as well as due to braking and thermal forces.
- They carry out the function of transmitting the load to a large area of the formation through sleepers and the ballast.

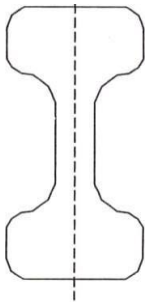
Requirements of an ideal Rail section:

- The rail should have the most economical section consistent with strength, stiffness, and durability.
- The centre of gravity of the rail section should preferably be very close to the mid-height of the rail so that the maximum tensile and compressive stresses are equal.
- A rail primarily consists of a head, a web, and a foot, and there should be an economical and balanced distribution of metal in its various components so that each of them can fulfill its requirements properly.
- The head of the rail should have adequate depth to allow for vertical wear. The rail head should also be sufficiently wide so that not only is a wider running surface available, but also the rail has the desired lateral stiffness.
- The web should be sufficiently thick so as to withstand the stresses arising due to the loads bore by it, after allowing for normal corrosion.
- The foot should be of sufficient thickness to be able to withstand vertical and horizontal forces after allowing for loss due to corrosion. The foot should be wide enough for stability against overturning. The design of the foot should be such that it can be economically and efficiently rolled.
- Fishing angles must ensure proper transmission of loads from the rails to the fish plates. The fishing angles should be such that the tightening of the plate does not produce any excessive stress on the web of the rail.
- Height of the rail should be adequate so that the rail has sufficient vertical stiffness and strength as a beam.

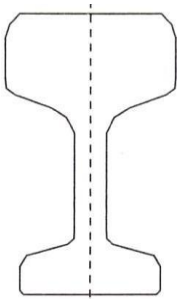
Types of Rails:

The rails used in the construction of railway track are of following types:

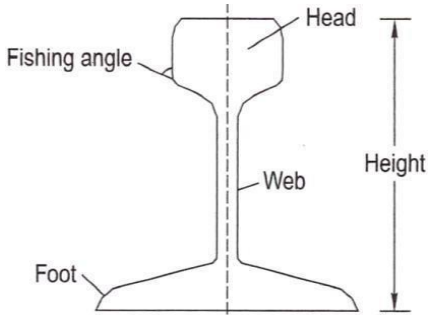
1. Double headed rails (D.H. Rails)
2. Bull headed rails (B.H.Rails)
3. Flat footed rails (F.F.Rails)



D.H. rail



B.H. rail



F.F. rail

Double headed rails:

The rail sections, whose foot and head are of same dimensions, are called Double headed or Dumb-bell rails. In the beginning, these rails were widely used in the railway track. The idea behind using these rails was that when the head had worn out due to rubbing action of wheels, the rails could be inverted and reused. But by experience it was found that their foot could not be used as running surface because it also got corrugated under the impact of wheel loads. This type of rail is not in use in Indian Railways now-days.

Bull headed rails:

The rail section whose head dimensions are more than that of their foot are called bull headed rails. In this type of rail the head is made little thicker and stronger than the lower part by adding more metal to it. These rails also require chairs for holding them in position. Bull headed rails are especially used for making points and crossings.

Merits:

- B.H. Rails keep better alignment and provide more smoother and stronger track.
- These rails provide longer life to wooden sleepers and greater stability to the track.
- These rails are easily removed from sleepers and hence renewal of track is easy

Demerits:

- B.H. rails require additional cost of iron chairs.
- These rails require heavy maintenance cost.
- B.H. rails are of less strength and stiffness.

Flat footed Rails:

The rail sections having their foot rolled to flat are called flat footed or vignole`s rails. This type of rail was invented by Charles Vignole in 1836. It was initially thought that the flat footed rails could by fixed directly to wooden sleepers and would eliminate chairs and keys required for the B.H. rails. But later on, it was observed that heavy train loads caused the foot of the rail to sink into the sleepers and making the spikes loose. To remove this defect, steel bearing plates were used in between flat footed rails and the wooden sleeper. These rails are most commonly used in India.

Merits:

- F.F. rails have more strength and stiffness.
- No chairs are required for holding them in position.
- These rails require less number of fastenings.
- The maintenance cost of track formed with F.F. rails is less.

Demerits:

- The fittings get loosened more frequently.
- These rails are not easily removed and hence renewal of track becomes difficult.
- It is difficult to manufacture points and crossings by using these rails.

Length of rail:

The longer is the rail, the lesser would be the number of joints and fittings required and the lesser the cost of construction and maintenance. Longer rails are economical and provide smooth and comfortable rides.

Indian Railways has standardized a rail length of 13 m (previously 42 ft) for broad gauge and 12 m (previously 39 ft) for MG and NG tracks.

RAIL JOINTS

Definition:

A rail joint is an integral part of the railway track as it holds together the adjoining ends of rails in correct position, both in horizontal and vertical planes.

Ill Effects of Rail joints:

A rail joint is the weakest link in the track. At a joint, there is a break in the continuity of the rail in both the horizontal and the vertical planes because of the presence of the expansion gap and imperfection in the levels of rail heads. A severe jolt is also experienced at the rail joint when the wheels of vehicles negotiate the expansion gap. This jolt loosens the ballast under the sleeper bed, making the maintenance of the joint difficult. The fittings at the joint also become loose, causing heavy wear and tear of the track material.

Requirements of an ideal rail joint:

An ideal rail joint provides the same strength and stiffness *a*s the parent rail. The characteristics of an ideal rail joint are briefly summarized here.

- ***Holding the rail ends*:** An ideal rail joint should hold both the rail ends in their precise location in the horizontal as well as the vertical planes to provide as much continuity in the track as possible. This helps in avoiding wheel jumping or the deviation of the wheel from its normal path of movement.
- ***Strength:*** An ideal rail joint should have the same strength and stiffness as the parent rails it joins.
- ***Expansion gap*:** The joint should provide an adequate expansion gap for the free expansion and contraction of rails caused by changes in temperature
- ***Flexibility*:** It should provide flexibility for the easy replacement of rails, whenever required.
- ***Provision for wear:*** It should provide for the wear of the rail ends, which is likely to occur under normal operating conditions.
- ***Elasticity*:** It should provide adequate elasticity as well as resistance to longitudinal forces so as to ensure a trouble-free track.
- ***Cost*:** The initial as well as maintenance costs of an ideal rail joint should be minimal.

Types of Rail Joints:

The nomenclature of rail joints depends upon the position of the sleepers or the joints.

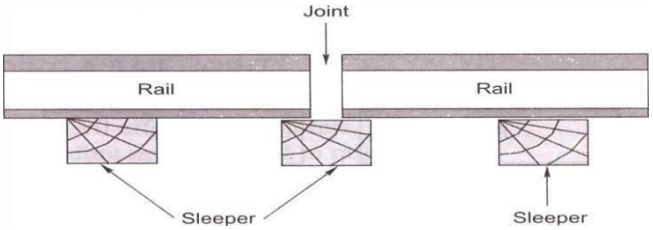
Classification According to Position of Sleepers:

Three types of rail joints come under this category.

i. Supported Joints
ii. Suspended Joints
iii. Bridge Joints

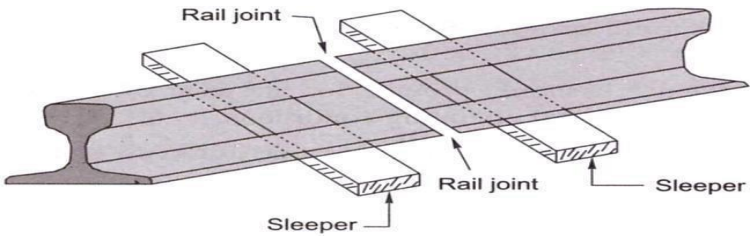
Supported joint:

In this type of joint, the ends of the rails are supported directly on a sleeper called as 'joint sleeper'. The support tends to slightly raise the height of the rail ends. As such, the run on a supported joint is normally hard. There is also wear and tear of the sleeper supporting the joint and its maintenance presents quite a problem. The duplex sleeper is an example of a supported joint.



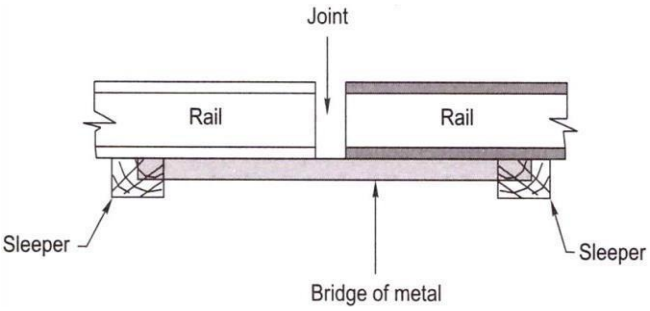
Suspended joint:

In this type of joint, the ends of the rails are suspended between two sleepers and some portion of the rail is cantilevered at the joint. As a result of cantilever action, the packing under the sleepers of the joint becomes loose particularly due to the hammering action of the moving train loads. Suspended joints are the most common type of joints adopted by railway systems worldwide, including India.

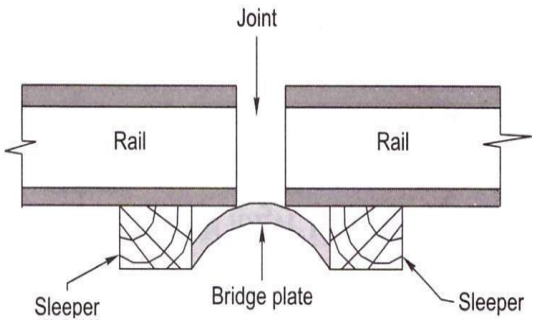


Bridge joints:

The bridge joint is similar to the suspended joint except that the two sleepers on either side of a bridge joint are connected by means of a metal flat or a corrugated plate known as a bridge plate. This type of joint is generally not used on Indian Railways.



(Bridge joint with metal flat Joint)



(Bridge joint with bridge plate)

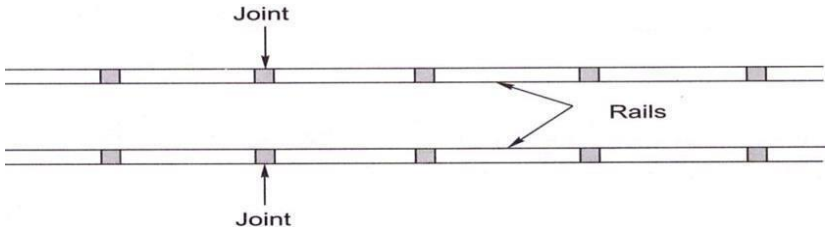
Classification Based on the Position of the Joint:

Two types of rail joints fall in this category.

i. Square Joints
ii. Staggered Joints

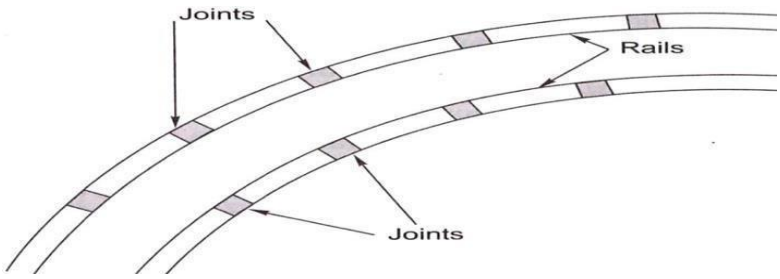
Square joint:

In this case, the joints in one rail are exactly opposite to the joints in the other rail. This type of joint is most common on Indian Railways.



Staggered joint:

In this case, the joints in one rail are somewhat staggered and are not opposite the joints in the other rail. Staggered joints are normally preferred on curved tracks because they hinder the centrifugal force that pushes the track outward.



CREEP OF RAILS

Definition:

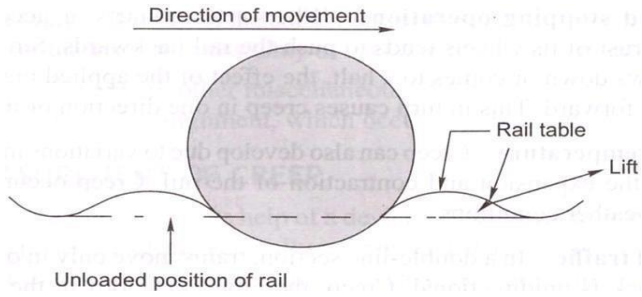
Creep of rails can be defined as the longitudinal movement of rails with respect to sleepers in a track. Rails have a tendency to gradually move in the direction of dominant traffic. Creep is common to all railway tracks, but its magnitude varies considerably from place to place; the rail may move by several centimetres in a month at few places, while at other locations the movement may be almost negligible.

Theories for the development of creep:

Various theories have been put forward to explain the phenomenon of creep and its causes, but none of them have proved to be satisfactory. The important theories are briefly discussed in the following subsections.

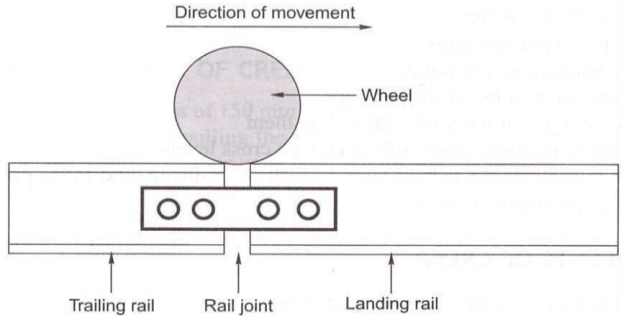
Wave Motion Theory:

According to wave motion theory, wave motion is set up in the resilient track because of moving loads, causing a deflection in the rail under the load. The portion of the rail immediately under the wheel gets slightly depressed due to the wheel load. Therefore, the rails generally have a wavy formation.



Percussion Theory:

According to percussion theory, creep is developed due to the impact of wheels at the rail end ahead of a joint. As the wheels of the moving train leave the trailing rail at the joint, the rail gets pushed forward causing it to move longitudinally in the direction of traffic, and that is how creep develops. Though the impact of a single wheel may be nominal, the continuous movement of several wheels passing over the joint pushes the facing or landing rail forward, thereby causing creep.



Drag Theory:

According to drag theory, the backward thrust of the driving wheels of a locomotive has the tendency to push the rail backwards, while the thrust of the other wheels of the locomotive and trailing wagons pushes the rail in the direction in which the locomotive is moving. This results in the longitudinal movement of the rail in the direction of traffic, thereby causing creep.

Causes of Creep:

The main factors responsible for the development of creep are as follows.

- **Ironing effect of the wheel:** The ironing effect of moving wheels on the waves formed in the rail tends to cause the rail to move in the direction of traffic, resulting in creep.

- **Starting and stopping operations** When a train starts or accelerates, the backward thrust of its wheels tends to push the rail backwards. Similarly, when the train slows down or comes to a halt, the effect of the applied brakes tends to push the rail forward. This in turn causes creep in one direction or the other.

- **Changes in temperature** Creep can also develop due to variations in temperature resulting in the expansion and contraction of the rail. Creep occurs frequently during hot weather conditions.

- **Unbalanced traffic** In a double-line section, trains move only in one direction, i.e., each track is unidirectional. Creep, therefore, develops in the direction of traffic. In a single-line section, even though traffic moves in both directions, the volume of traffic in each direction is normally variable. Creep, therefore, develops in the direction of predominant traffic.

- **Poor maintenance of track** Some minor factors, mostly relating to poor maintenance of the track, also contribute to the development of creep. These are as follows:
    - Improper securing of rails to sleepers
    - Limited quantities of ballast resulting in inadequate ballast resistance to the movement of sleepers
    - Improper expansion gaps
    - Badly maintained rail joints
    - Rail seat wear in metal sleeper track
    - Rails too light for the traffic carried on them
    - Yielding formations that result in uneven cross levels
    - Other miscellaneous factors such as lack of drainage, and loose packing, uneven spacing of sleepers

SLEEPERS

Definition:

Sleepers are transverse members of the track placed below the rails to support and fix them in position.

Functions of Sleepers:

Sleepers serve the following functions:

- To hold the rails to proper gauge.
- To transfer the loads from rails to the ballast.
- To support and fix the rails in proper position.
- To keep the rails at a proper level in straight tracks and at proper super elevation on curves.
- To provide elastic medium between the rails and the ballast.
- To provide stability to the permanent way on the whole.

Requirements of good sleepers:

The following are the requirements of good sleepers:

- The sleepers should be sufficiently strong to act as a beam under loads.
- The sleepers should be economical.
- They should maintain correct gauge.
- They should provide sufficient bearing area for the rail.
- The sleepers should have sufficient weight for stability.
- Sleepers should facilitate easy fixing and taking out of rails without disturbing them.
- They should facilitate easy removal and replacement of ballast.
- They should not be pushed out easily of their position in any direction under maximum forces of the moving trains.
- They should be able to resist impact and vibrations of moving trains.
- They should be suitable to each type of ballast.
- If track-circuiting is done, it should be possible to insulate them from the rails.

Types of Sleepers:

Sleepers are of the following types:

1. Wooden sleepers.
2. Steel sleepers.
3. Cast iron sleepers.
4. R.C.C. sleepers.
5. Pre stressed concrete sleepers.

1. Wooden Sleepers:

These sleepers are regarded to be the best as they satisfy all the requirements of good sleepers and are the only sleeper suitable for track circuiting. The life of wooden sleepers depends upon their ability to resist wear, attack by white ants and quality of timber used. Timbers commonly used in India for sleepers are Sal, Teak, Deodar and chair wood.

The standard sizes of wooden sleepers for different gauges are as follows:
For B.G. – 2740 mm X 250 mm X 130 mm
For M; .G. – 1830 mm X 203 mm X 114 mm
For N.G. – 1520 mm X 150 mm X 100 mm

Advantages:

- Timber is easily available in all parts of India.
- Wooden sleepers are suitable for all types of ballast.
- Wooden sleepers require less fastening and simple in design.
- These sleepers give less noisy track.
- These sleepers absorb shocks and vibrations more than any other sleepers.
- These sleepers are best suited for track circuiting.

Disadvantages:

- The life of wooden sleeper is less as compared to other types of sleepers.
- It is difficult to maintain gauge of the track in case of wooden sleepers.
- These sleepers are subjected to wear, decay, and attack by white ants etc.
- Track laid over wooden sleepers is easily disturbed.
- Maintenance cost is more as compared to other sleepers.

2. Steel Sleepers:

These sleepers consist of steel troughs made of 6 mm thick sheets, with its both ends bend down to check the running out of ballast. At the time of pressing of sleepers, an inward slope of 1 in 20 on either side is provided to achieve required tilt of rails. The standard length of these is 2680 mm.

Steel sleepers are of two types:

I. Key type steel sleepers
II. Clip and bolt type steel sleepers

Key type steel sleepers:

In this type of sleepers lugs or jaws are pressed out of metal and keys are used for holding the rails. These are of two types:

a. Lug type
b. Loose jaw type

Clip and bolt type steel sleepers:

In this type of sleeper, clips and bolts are used for holding the rails. Cracks are not developed in the sleepers as the holes for the bolts are small and circular. It requires four clips and four bolts for holding each rail.

Advantages:

- Steel sleepers are light in weight and can be handled easily.
- These require fewer fastenings.
- The life of steel sleepers is more than the wooden sleepers.
- The gauge can be easily maintained and adjusted.
- The scrap value is more than the wooden sleepers.
- The track laid on steel sleepers has good lateral and longitudinal rigidity.
- Creep of rails can be checked by using steel sleepers.

Disadvantages:

- Initial cost of these sleepers is more than wooden sleepers.
- Cracks are developed at rail seat of these sleepers.
- Steel sleepers are not suitable for track circuiting.
- These are not suitable for all types of ballast.
- These are liable to corrosion.

3. Caste Iron Sleepers:

The sleepers made of cast iron, known as cast iron sleepers, have been extensively used in India as compared to other countries in the world. Cast iron sleepers are of the following types:

I. Pot or bowl sleeper
II. Plate sleeper
III. Box sleeper
IV. CST-9 sleeper
V. Duplex sleeper

Pot or bowl sleeper:

Pot sleeper consist of two bowls placed under each rail and connected together by a tie-bar. The total effective area of both the pots is 0.464 sq. m. Each pot is provided with two holes foe inspection and packing of ballast. On the top of each pot, a rail seat is provided to hold rails at an inward slope of 1 in 20. Gibbs and cotters are so casted that by interchanging them gauge is slackened by 3 mm.

Plate sleeper:

Plate sleepers consist of two rectangular plates of 864 mm X 305 mm in size with short side parallel to rail. The plates are provided with projecting ribs in the bottom to provide a grip in the ballast for lateral stability. The plates are held in position by tie-bar. Stiffeners are provided at the top of the plate to increase the strength. It provides the effective bearing area of 0.464sq. m per sleeper.

Box Sleeper:

These sleepers are not in user these days. Box sleepers are similar to plate sleepers. In this type of sleeper, a box is provided at the top of each plate to hold the rails.

CST-9 Sleeper:

CST-9 sleeper is more satisfactory than other C.I. Sleepers and is extensively used in Indian Railways since last thirty years. It is a combination of pot, plate, and box sleeper. CST-9s sleeper consists of a triangular inverted pot one on each side of rail seat. Rail seat is provided at the top to hold rails at 1 in 20 inward slope. The pots are connected across the track by means of a tie- bar.

Duplex Sleepers:

Duplex sleepers are also known as rail free duplex sleepers and have been used at rail joints in conjunction with CST_9 sleepers. These sleepers are used at rail joints to prevent cantilever action between two supports of the CST-9 sleepers. These consist of two plates, each of size 850 mm X 750 mm. The plates are placed with the longer side parallel to the rails and are connected with a tie-bar.

Advantages:

- The life of C.I sleepers is more.
- The maintenance cost of these sleepers is low.
- Gauge can be easily maintained and adjusted with these sleepers.
- These sleepers are more durable.
- Creep rails can be checked by using these sleepers.

Disadvantages:

- More ballast is required than any other type of sleepers.
- The number of fittings required is more.
- These sleepers are liable to break.
- C.I. Sleepers are liable to break.
- These are not suitable for all types of ballast.

4. R.C.C. Sleepers:

Reinforced cement concrete sleepers are of two types:
(i) Through type
(ii) Block and tie type

Through type R.C.C. Sleeper:

This is also known as one piece or mono-block sleeper. In this type of sleeper cracks develop on the tension side when stressed. These cracks are very small and almost invisible but tend to enlarge with the repetition of impact loading, causing failure.

Block and tie type R.C.C. Sleeper:

This type of sleeper consists of two R.C.C. blocks connected by a metal tie of inverted T-section. These sleepers are not subjected to any degree of tensile stress as in through type.

Advantages:

- Concrete sleepers have long life, generally 40to 60 years.
- These are free from natural decay and attack by insects etc.
- These sleepers require less fittings.
- Track circuiting is possible in these sleepers.
- These sleepers provide more lateral and longitudinal rigidity as compared to other sleepers.
- The maintenance cost is low.
- Due to higher elastic modulus, these can withstand the stresses due to fast moving trains.

Disadvantages:

- Due to heavy weight, handling and transportation of these sleepers are difficult.
- If not handled properly, the chance of breaking is more.
- The renewal of track laid with these sleepers is difficult.
- The scrap value is nil.

5. Pre stressed Concrete Sleepers:

Pre stressed concrete sleepers are now-a-days extensively used in Indian Railways. These sleepers have high initial cost but are very cheap in long run due to their long life. In these sleepers, high tension steel wires are used. These wires are stretched by hydraulic jack to give necessary tension in the wires. The concrete is then put under a very high initial compression. These sleepers are heavily damaged in case of derailment or accidents of trains.

BALLAST

Definition:

Ballast is a layer of broken stones, gravel, rnoorum, or any other granular material placed and packed below and around sleepers for distributing load from the sleepers to the formation. It provides drainage as well as longitudinal and lateral stability to the track.

Functions of Ballast:

The ballast serves the following functions in a railway track.

- It provides a level and hard bed for the sleepers to rest on.
- It holds the sleepers in position during the passage of trains.
- It transfers and distributes load from the sleepers to a large area of the formation.
- It provides elasticity and resilience to the track for proper riding comfort.
- It provides the necessary resistance to the track for longitudinal and lateral stability.
- It provides effective drainage to the track.
- It provides an effective means of maintaining the level and alignment of the track.

Requirements of good ballast:

- It should have sufficient strength to resist crushing under heavy loads of moving trains.
- It should be durable enough to resist abrasion and weathering action.
- It should have rough and angular surface so as to provide good lateral and longitudinal stability to the sleepers.
- It should have good workability so that it can be easily spread of formation.
- It should be cheaply available in sufficient quantity near and along the track.
- It should not make the track dusty or muddy due to its crushing to powder under wheel loads.
- It should allow for easy and quick drainage of the track.
- It should not have any chemical action on metal sleepers and rails.

Types of Ballast:

In India, the following materials are used as ballast.

1. Broken stone
2. Gravel
3. Sand
4. Ashes or Cinders
5. Kankar
6. Moorum
7. Blast furnace slag
8. Brick ballast
9. Selected earth

1. Broken Stone:

This is the best type of ballast as it possesses all the characteristics of good ballast. It holds the track to correct alignment and gradient due to its high interlocking action. The stones which are non porous, hard and do not flake on breaking should be used. Igneous rocks such as granite, quartzite and trap make excellent ballast. This type of ballast is used for high speed tracks.

Advantages:

- It is hard and resists crushing under heavy loads.
- It has angular and rough surface and hence gives more stability to the sleepers.
- Its drainage property is excellent.

Disadvantages:

- It is expensive.
- It is not so easily available.

2. Gravel:

Gravel is the second best material for ballast. This is obtained either from river beds or from gravel pits and has smooth rounded fragments. Gravel obtained from pits usually contains earth which should be removed by washing. Gravel obtained from river beds is screened and required size gravel is used. Larger size gravels are broken into required size. Round edges gravels are broken to increase their interlocking action.

Advantages:

- Gravel is cheaper than stone ballast.
- The drainage property is excellent'
- It holds the track to correct alignment and gradient.
- It is easy to use gravel ballast than stone ballast in certain places where formation is unstable.

Disadvantages:

- It requires screening before use due to large variation in size.
- Gravel obtained from pits requires washing.
- Due to round faces the packing under sleeper is loose.
- Gravel rolls down easily due to vibrations.

3. Sand:

Sand is reasonably a good material for the ballast. Coarse sand is generally preferred to fine sand for ballast. This type of ballast is suitable for packing pot sleepers. It is used only on unimportant tracks.

Advantages:

- It is a cheaper ballast material.
- It has very good drainage quality.
- It is available in large quantities and hence can be used in emergency.
- Sand ballast produces a silent track.

Disadvantages:

- It has no stability and gets disturbed by the vibrations caused by moving train.
- It causes wear of rail, seats and keys.

4.Ashes or Cinders:

These are waste products obtained from steam locomotives. This type of ballast is normally used in yards and sidings or as the initial ballast in new constructions.

Advantages:

- It is a cheaper ballast material.
- It has very good drainage quality.
- It is available in large quantities and hence can be used in emergency.
- The handling and transportation are easy.

Disadvantages:

- It is very soft and gets crumbled to powder under heavy loads.
- It has got corrosive quality and corrodes steel sleepers and foot of the rails.

5. Kankar:

It is natural material in the form of nodules from which lime is prepared.

Advantages:

- It is cheaper.
- It has good drainage property.

Disadvantages:

- It is soft and crumbles to powder under traffic load.
- The tracks laid on kankar ballast are difficult to maintain.
- It has corrosive quality.

6. Moorum:

It is a soft aggregate and is obtained by the decomposition of laterite. It has red or yellow colour. It is used in unimportant lines and sidings.

Advantages:

- It is easily available in most parts of India.
- It has good drainage properties.
- It is used as blanket for new embankment.

Disadvantages:

- It is soft and easily crumbles to powder under heavy loads.
- Maintenance of track laid on moorum ballast is very difficult.

7. Blast furnace slag:

It is a waste product obtained from the blast furnace of steel industry. High grade slag fulfils all the characteristics of good ballast.

Advantages:

- It is a cheap material.
- It has good drainage properties.
- It is a strong material.
- It holds the track in correct alignment and gradient.

Disadvantages:

- It is not available in large quantity.
- Spreading of this material on the formation is difficult.
- Maintenance of track laid on slag ballast is difficult.

8. Brick Ballast:

At places where good ballast material is not available over-burnt bricks are broken into suitable size to be used as ballast.

Advantages:

- It is a cheap material.
- It prevents growth of vegetation.
- It has good drainage properties.

Disadvantages:

- It is soft and easily crumbles to powder under heavy loads.
- The rails laid over such ballast get corrugated.

9. Selected Earth:

Hardened clay and decomposed rock are suitable for use as ballast. When tracks are laid on new formation, then sleepers are packed with earth for a few months. When the formation is consolidated and surface becomes hard, good type of ballast is laid. The use of earth ballast in the beginning is to prevent the loss of good ballast by sinking into soft formation.

FIXTURES AND FASTENINGS

Definition:

Fixtures and fastenings are fittings required for joining of rails end to end and also for fixing the rails to sleepers in a track.

Functions of Fixtures and Fastenings:

Rail fixtures and fastenings have the following functions:

- To join the rails end to end to form full length of track.
- To fix the rails to sleepers.
- To maintain the correct alignment of the track.
- To provide proper expansion gap between rails.
- To maintain the required tilt of rails.
- To set the points and crossings in proper position.

Types of Fixtures and Fastenings:

Fixtures and fastenings commonly used in a permanent way are of following types:

1. Fish plates
2. Bearing plates
3. Spikes
4. Chairs
5. Bolts
6. Keys
7. Anti creepers

Fish Plates:

Fish plates are used in rail joints to maintain the continuity of the rails. Two types of fish plates are commonly used on Indian Railways for joining F.F. and B.H. rails, each fish plate is 457 mm long and provided with four holes 32 mm dia. at a spacing of 114 mm c/c. These are manufactured of steel and are so designed that they fit in between the head and foot of the rail.

Bearing Plates:

Bearing plates are cast iron or steel plates placed in between the F.F rail and wooden sleepers of a railway track. F.F. rails if fixed directly on wooden sleepers sink in the sleeper due to the heavy loads of trains and thus loosen the spikes. To overcome this difficulty bearing plates are used under F.F. rails to distribute the load over a wider area and bring the intensity of pressure within limit. Bearing plates give the required 1 in 20 inward slope to the rail directly and no adzing is required in the wooden sleeper. These are fixed to sleepers by spikes.

Spikes:

Spikes are used to fix rails to wooden sleepers. Spikes are of following types:

(a) Dog spikes
(b) Round spikes
(c) Screw spikes
(d) Elastic spikes

- **Dog spikes** are the cheaper type of spikes which hold the rails at correct gauge and can be easily fixed and removed. These are commonly used for holding F.F. rails. Four dog spikes are used per sleeper, two on either side of the rail. The disadvantage of dog spikes is that these become loose under the wave action caused by the moving train.

- **Round spikes** are used for fixing chairs of B.H. rails to wooden sleepers and also for fixing slide chairs of points and crossings. These have either cylindrical or hemispherical head or blunt end.

- **Screw spikes** are tapered screws with V-threads. Their head is circular with a square projection and are used to fasten rails with wooden sleepers. The holding power of these spikes is more than double to that of dog spikes and can resist the lateral thrust better than the dog spikes.

- **Elastic spikes** are used for fixing F.F. rails to wooden sleepers. These give better grip and result in reduction of wear and tear of rail. The advantage of this type of spike is that it is not pulled up by the wave action of the moving train.

Bolts:

Different types of bolts used in Indian Railway are:

(a) Fish bolts
(b) Hook bolts
(c) Fang bolts

- **Fish bolts** are used for connecting fish plates with the rails. Four bolts are required for each pair of fish plates. These bolts are inserted from outside the track and bolted on the inside of the track.
- Fish bolts have to withstand shear due to heavy transverse stresses, hence they are manufactured of medium or high carbon steel. The length of fish bolt depends on the type of fish plate used. For 44.70kg rail, the fish bolts of 25 mm dia and 127.6 mm length are used. These bolts get loosened due to vibration of moving train and hence these are to be tightened time ot time. Too much tightening of bolts is prohibited as it prevents free expansion or contraction of rails due to temperature vibrations.

- **Hook bolts** are also known as dog bolts due to the shape of their heads. These bolts are used to fix sleepers which rest directly on a girder. Two bolts per sleeper are used. Dog bolts are of two types.
  (i) Sloping lips- for fixing sleepers to plate girder spans.
  (ii) Straight lips- for fixing sleepers to joist spans.

- **Fang bolts** are used for fixing side chairs to sleepers. These are alternative to screw or round spikes. The fang bolts are found to be more effective but are not generally used, because fixing and removal of these bolts are difficult.

Keys:

These are small tapered pieces of timber or steel used to fix rails to chairs on metal sleepers. Keys are of two types

1. Wooden keys
2. Metal keys

- **Wooden keys** are small straight or tapered pieces of timber. These are cheap and easily prepared. These are not strong and become loose under vibrations. These require frequent maintenance. Wooden keys are not used now-a days in Indian Railways.

- **Metal keys** are small tapered or spring like pieces of steel. These keys are much more durable than wooden keys. Metal keys are of two types.
  (i) Stuart`s key and
  (ii) Morgan key

Anti-Creepers:

Anti-creepers are used to prevent creep in a railway track. Different shapes of anti-creepers are available and are fixed to the foot of rail.