MODULE-III: RAILWAY ENGINEERING

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

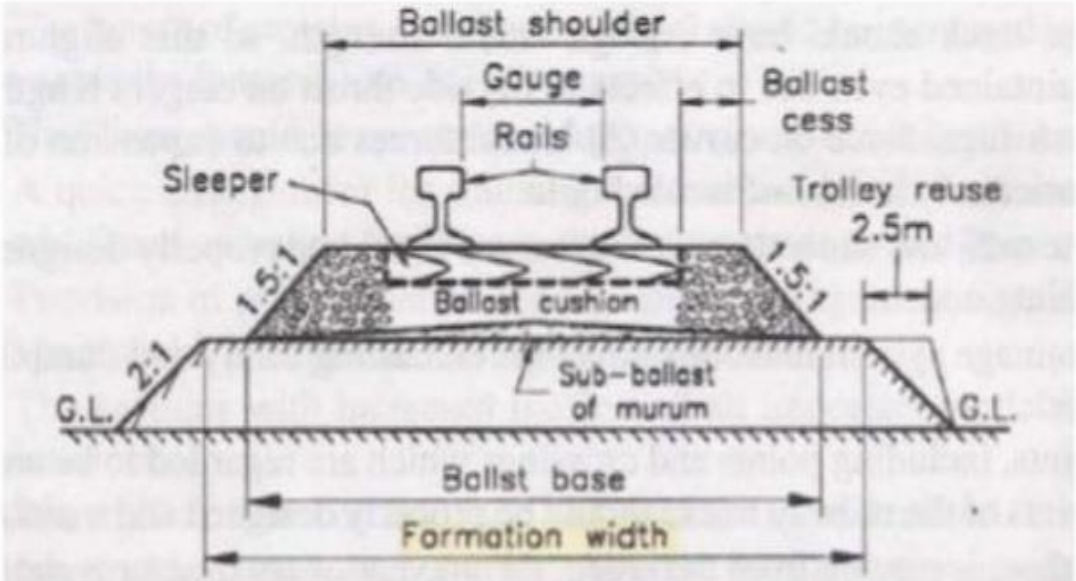
PERMANENT WAY

• The finished or completed track of a railway line is commonly known as permanent way.

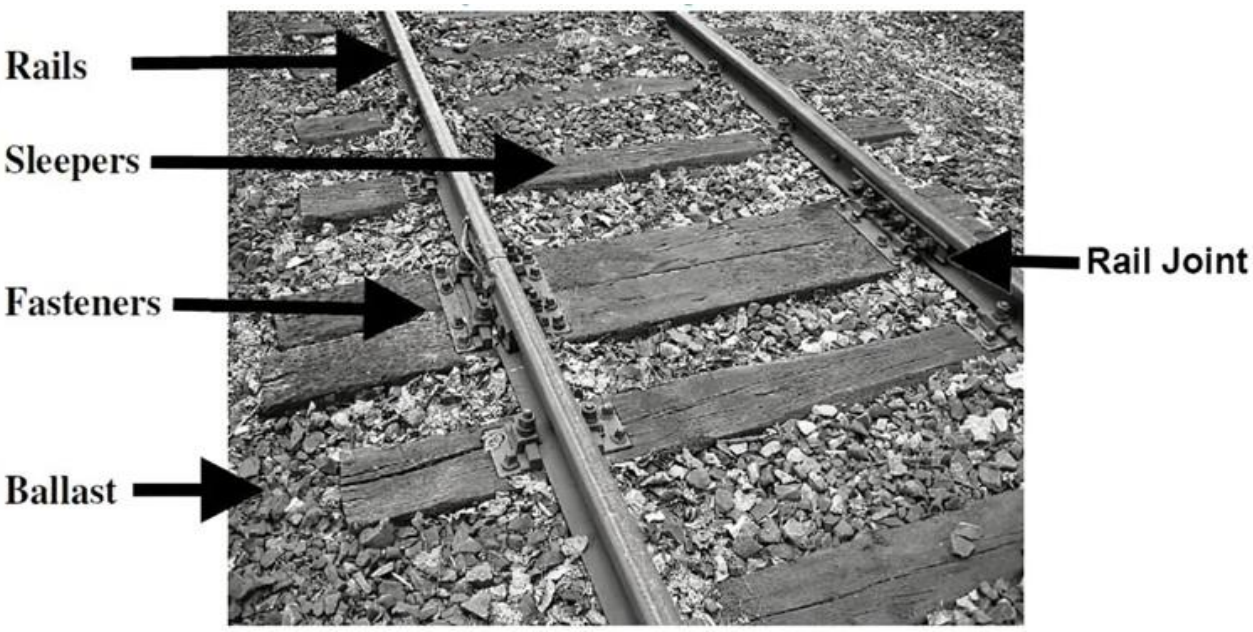
• A permanent way or a railway track can be defined as the combination of rails, fitted on sleepers and resting on ballast and sub grade.

• It essentially consist of 3 parts:

- Rails
- Sleepers
- Ballast
- Fasteners



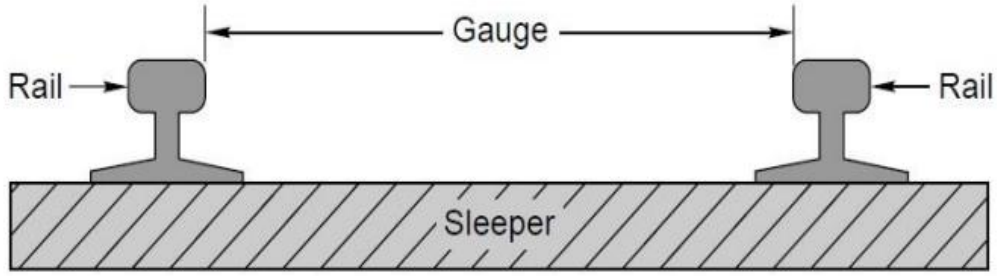
Typical Cross-section of a Permanent Way on Embankment.



GAUGE

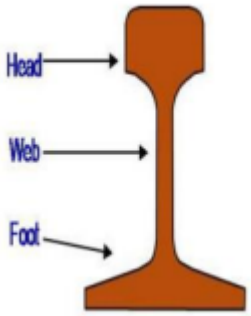
• Gauge is defined as the minimum distance between two rails.

• Indian Railways follows this standard practice and the gauge is measured as the clear minimum distance between the running faces of the two rails.



RAILS

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.



Function of rails

• Rails provide a continuous and level surface for the movement of trains.

• Rails 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.

• Rails serve as a lateral guide for the wheels.

• Rails 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.

• Rails 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 fulfil its requirements properly.

Types of Rails:

1. DOUBLE HEADED RAILS
2. BULL HEADED RAILS
3. FLAT FOOTED RAILS

RAIL JOINTS

• 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.

Requirements of an ideal rail joint:

• 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.

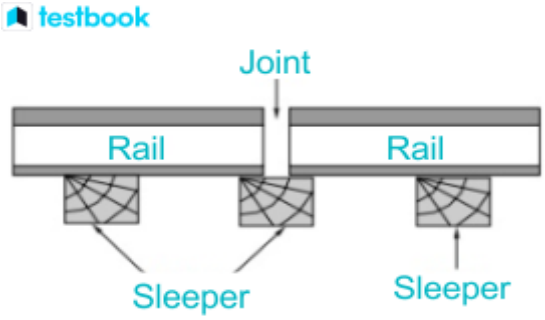
• Elasticity: It should provide adequate elasticity as well as resistance to longitudinal forces so as to ensure a trouble-free track.

• Cost: The initial as well as maintenance costs of an ideal rail joint should be minimal.

Types of Rail Joints:

Supported joint:

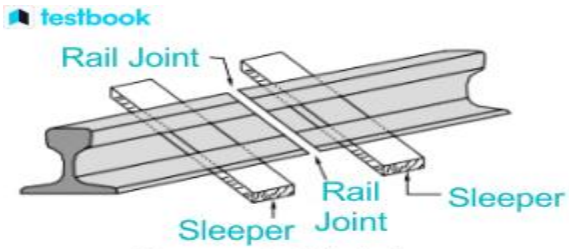
• In this type of joint, the ends of the rails are supported directly on a sleeper called as ‘joint sleeper’. The support tends to slightly raise the height of the rail ends. As such, the run on a supported joint is normally hard. There is also wear and tear of the sleeper supporting the joint and its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



Supported Joint

Suspended joint:

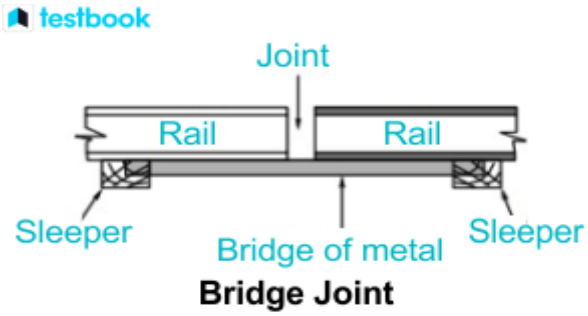
• In this type of joint, the ends of the rails are suspended between two sleepers and some portion of the rail is cantilevered at the joint. As a result of cantilever action, the packing under the sleepers of the joint becomes loose particularly due to the hammering action of the moving train loads.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



Suspended Joint

Bridge joints:

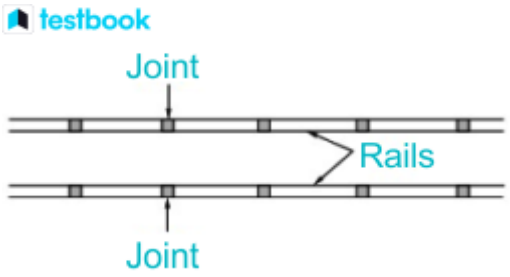
• The bridge joint is similar to the suspended joint except that the two sleepers on either side of a bridge joint are connected by means of a metal flat or a corrugated plate known as a bridge plate. This type of joint is generally not used on Indian Railways.



Bridge Joint

Square joint:

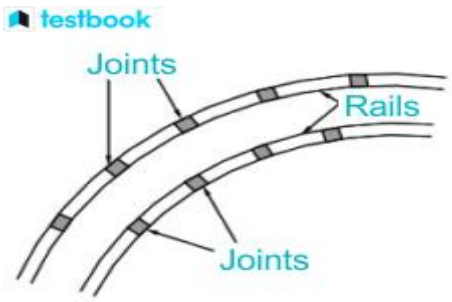
• In this case, the joints in one rail are exactly opposite to the joints in the other rail. This type of joint is most common on Indian Railways.



Square Joint

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.



Staggered Joint

CREEP OF RAIL:

Creep is defined as the longitudinal movement of the rail with respect to the sleepers. 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.

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 the 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 the poor maintenance of the track, also contribute to the development of creep. These are as follows.

(a) Improper securing of rails to sleepers

(b) Limited quantities of ballast resulting in inadequate ballast resistance to the movement of sleepers

(c) Improper expansion gaps

(d) Badly maintained rail joints

(e) Rail seat wear in metal sleeper track

(f) Rails too light for the traffic carried on them

(g) Yielding formations that result in uneven cross levels

(h) Other miscellaneous factors such as lack of drainage, and loose packing, uneven spacing of sleepers.

Prevention of creep

- Pulling back the rail to original position.
- Pulling of anchors and anti creepers should be done .
- One should increase no of sleepers per rail length.
- One should provide sufficient ballast and packing with care.
- For good grip steel sleepers are used.

SLEEPERS

Sleepers are the transverse ties that are laid to support the rails. They have an important role in the track as they transmit the wheel load from the rails to the ballast. Several types of sleepers are in use on Indian Railways.

Functions of sleepers

The main functions of sleepers are as follows.

(a) Holding the rails in their correct gauge and alignment

(b) Giving a firm and even support to the rails

(c) Transferring the load evenly from the rails to a wider area of the ballast

(d) Acting as an elastic medium between the rails and the ballast to absorb the blows and vibrations caused by moving loads

(e) Providing longitudinal and lateral stability to the permanent way

(f) Providing the means to rectify the track geometry during their service life.

Types of Sleepers

The sleepers mostly used on Indian Railways are :

(i) wooden sleepers,

(ii) cast iron (CI) sleepers

(iii) steel sleepers

(iv) concrete sleepers

Wooden Sleepers

The wooden sleeper is the most ideal type of sleeper, and its utility has not decreased with the passage of time.

Advantages

(a) Cheap and easy to manufacture

(b) Absorbs shocks and bears a good capacity to dampen vibrations; therefore, retains the packing well .

(c) Easy handling without damage

(d) Suitable for track-circuited sections

(e) Suitable for areas with yielding formations

Disadvantages

(a) Lesser life due to wear, decay, and attack by vermin

(b) Liable to mechanical wear due to beater packing

(c) Difficult to maintain the gauge.

Steel Trough Sleeper

About 27% of the track on Indian Railways is laid on steel sleepers. The increasing shortage of timber in the country and other economical factors are mainly responsible for the use of steel sleepers in India.

Disadvantages

(a) Liable to corrode

(b) Unsuitable for track-circuited areas

Cast Iron Sleepers

Cast iron sleepers are being extensively used on Indian Railways and about 45% of the track at present consists of CI sleepers, which may be either pot type or plate type. The main advantages and disadvantages of CI sleepers over steel trough sleepers are the following:

Advantages

(a) Less corrosion

(b) Less probability of cracking at rail seat

(c) Easy to manufacture

(d) Higher scrap value

Disadvantages

(a) Gauge maintenance is difficult as tie bars get bent

(b) Provides less lateral stability

(c) Unsuitable for track-circuited lines

Concrete sleepers

Advantages

(a) Concrete sleepers, being heavy, lend more strength and stability to the track and are specially suited to LWR due to their great resistance to buckling of the track.

(b) Concrete sleepers with elastic fastenings allow a track to maintain better gauge, cross level, and alignment. They also retain packing very well.

(c) Concrete sleepers, because of their flat bottom, are best suited for modern methods of track maintenance such as MSP and mechanical maintenance, which have their own advantages.

(d) Concrete sleepers can be used in track-circuited areas, as they are poor conductors of electricity.

(e) Concrete sleepers are neither inflammable nor subjected to damage by pests or corrosion under normal circumstances.

(f) Concrete sleepers have a very long lifespan, probably 40–50 years. As such rail and sleeper renewals can be matched, which is a major economic advantage.

Disadvantages

(a) Handling and laying concrete sleepers is difficult due to their large weights. Mechanical methods, which involve considerable initial expenditure, have to be adopted for handling them.

(b) Concrete sleepers are heavily damaged at the time of derailment.

(c) Concrete sleepers have no scrap value.

(d) Concrete sleepers are not suitable for beater packing.

(f) Concrete sleepers should preferably be maintained by heavy ‘on track’ tampers.

BALLAST

Functions of Ballast

The ballast serves the following functions in a railway track.

• Provides a level and hard bed for the sleepers to rest on.

• Holds the sleepers in position during the passage of trains.

• Transfers and distributes load from the sleepers to a large area of the formation.

• Provides elasticity and resilience to the track for proper riding comfort.

• Provides the necessary resistance to the track for longitudinal and lateral stability.

• Provides effective drainage to the track.

• Provides an effective means of maintaining the level and alignment of the track.

Requirements of a Good Ballast

Ballast material should possess the following properties.

(a) It should be tough and wear resistant.

(b) It should be hard so that it does not get crushed under the moving loads.

(c) It should be generally cubical with sharp edges.

(d) It should be non-porous and should not absorb water.

(e) It should resist both attrition and abrasion.

(f) It should be durable and should not get pulverized or disintegrated under adverse weather conditions.

(g) It should allow for good drainage of water.

(h) It should be cheap and economical.

FIXTURES AND FASTENINGS

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:

• 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:

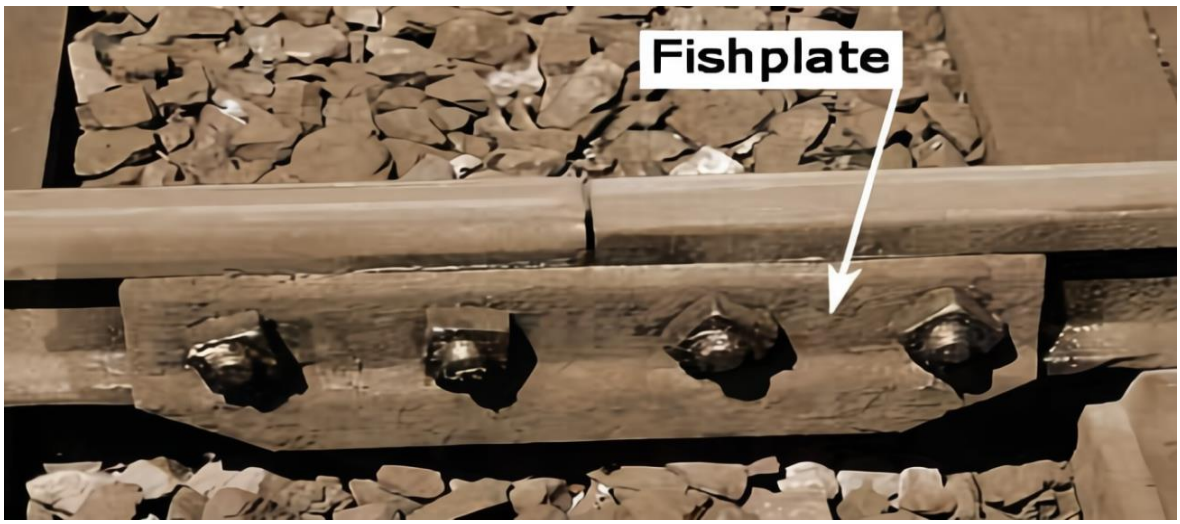
• Fixtures and fastenings commonly used in a permanent way are of following types:

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.

Chairs :

• They are used to hold the double headed and bull headed rails in required position.

They are made of cast iron having two jaws and a rail seat. In order to fix the double headed or bull headed rail to a chair, the rail is placed between the two jaws of the chair.

Fish bolt

Fish bolt is used for connecting the rail ends with the help of rail joints. Each rail joint needs at least two fish bolts according to the rail standard, and the bolt should be in proper size and suitable place. Rail bolt is usually used with spring washer and nut to fasten the rail tightly. The size of rail bolts varies as the variation of the rails or fish plate.