

Railway Engineering:

Component Parts Of A Permanent Way

Following are the components of a permanent way.

- (i) Sub-grade or formation
- (ii) Ballast
- (iii) Sleepers
- (iv) Rails
- (v) Fixture and Fastening

In a permanent way, rails are joined either by welding or by using fish plates and are fixed with sleepers by using different types of fastenings. Sleepers are properly placed and packed with ballast. Ballast is placed on the prepared sub-grade called formation.

Requirements of An Ideal Permanent Way

Following are the basic requirements of a permanent way:

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

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)

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-a 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

- (i) B.H. Rails keep better alignment and provide more smoother and stronger track.
- (ii) These rails provide longer life to wooden sleepers and greater stability to the track.

(iii) These rails are easily removed from sleepers and hence renewal of track is easy.

Demerits

- (i) B.H. rails require additional cost of iron chairs.
- (ii) These rails require heavy maintenance cost.
- (iii) 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 be 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

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

Demerits

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

SLEEPERS

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:

- (i) To hold the rails to proper gauge.
- (ii) To transfer the loads from rails to the ballast.
- (iii) To support and fix the rails in proper position.
- (iv) To keep the rails at a proper level in straight tracks and at proper super elevation on curves.
- (v) To provide elastic medium between the rails and the ballast.

(vi) To provide stability to the permanent way on the whole.

Requirements of Good Sleepers

The following are the requirements of good sleepers:

- (i) The sleepers should be sufficiently strong to act as a beam under loads.
- (ii) The sleepers should be economical.
- (iii) They should maintain correct gauge.
- (iv) They should provide sufficient bearing area for the rail.
- (v) The sleepers should have sufficient weight for stability.
- (vi) Sleepers should facilitate easy fixing and taking out of rails without disturbing them.
- (vii) They should facilitate easy removal and replacement of ballast.
- (viii) They should not be pushed out easily of their position in any direction under maximum forces of the moving trains.
- (ix) They should be able to resist impact and vibrations of moving trains.
- (x) They should be suitable to each type of ballast.
- (xi) 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. Prestressed 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:

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

Disadvantages

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

2. Steel Sleepers: These sleepers consist of steel throughs 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:

- (a) Key type steel sleepers.
- (b) Clip and bolt type steel sleepers.

(a) 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:

- (i) Lug type
- (ii) Loose jaw type

Lugs are formed by pressing out the metal of the channel section loose jaw type is an improvement on pressed lug type. Fig.5.2 shows key type steel sleepers.

(b) Clip and bolt type steel sleepers: In this type of sleeper, clips and bolts are used for holding the rails as shown in Fig.5.3. 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

- (i) Steel sleepers are light in weight and can be handled easily.
- (ii) These require less fastenings.
- (iii) The life of steel sleepers is more than the wooden sleepers.

- (iv) The gauge can be easily maintained and adjusted.
- (v) The scrap value is more than the wooden sleepers.
- (vi) The track laid on steel sleepers has good lateral and longitudinal rigidity.
- (vii) Creep of rails can be checked by using steel sleepers.

Disadvantages

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

3. Cast 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

- i. **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 for 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. Gibs and cotters are so casted that by interchanging them gauge is slackened by 3 mm.
- ii. **Plate sleeper:** Plate sleepers consists 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. Stiffners are provided at the top of the plate to increase the strength. For mixing of rails suitable arrangement is done as shown in Fig.5.6. It provides the effective bearing area of 0.464sq. m per sleeper.
- iii. **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.
- iv. **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. Fig.5.7 shows CST-9 sleeper.

- v. **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 consists 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 of C.I sleepers:

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

Disadvantages

- (i) More ballast is required than any other type of sleepers.
- (ii) The number of fittings required is more.
- (iii) These sleepers are liable to break.
- (iv) C.I. Sleepers are liable to break.
- (v) 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

(i)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.

(ii)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 of R.C.C. Sleepers

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

Disadvantages

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

5. Prestressed Concrete Sleepers:

Prestressed 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 caser of derailment or accidents of trains.

BALLAST

Ballast is the granular material usually broken stone or any other suitable material which is spread on the top of railway formation and around the sleepers.

Functions of Ballast

Ballast in railway track performs the following functions.

- (i) To hold the sleepers in position and preventing the lateral and longitudinal movement.
- (ii) To distribute the axle load uniform from sleepers to a large area of formation.
- (iii) To provide elasticity to the track. It acts as as elastic mat between subgrade and sleepers.
- (iv) To provide easy means of maintaining the correct levels of the two rails in a track.
- (v) To drain rain water from the track.
- (vi) To prevent the growth of weeds inside the track..

Characteristics of Good Ballast

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

(viii) It should not have any chemical action on metal sleepers and rails.

Types of Ballast

In India, the following materials are used as ballast.

- (i) Broken stone.
- (ii) Gravel
- (iii) Sand
- (iv) Ashes or cinders
- (v) Kankar
- (vi) Moorum
- (vii) Blast furnace slag
- (viii) Brick ballast
- (ix) Selected earth

(I)Broken Stone: This is the best type of ballast as it possesses all the characteristics of a 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:

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

Disadvantages

- (a) It is expensive.
- (b) It is not so easily available.

(ii)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:

- (a) Gravel is cheaper than stone ballast.
- (b) The drainage property of gravel excellent.
- (c) It holds the track to correct alignment and gradient.

(d) It is east to use gravel ballast than stone ballast at certain places where formation is unstable.

Disadvantages :

- (a) It requires screening before use due to large variation in size.
- (b) Gravel obtained from pits requires washing.
- (c) Due to round faces the packing under sleepers is loose.
- (d) Gravel easily roll down due to vibrations.

(iii) 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

- (a) It is a cheap material.
- (b) It is available in large quantities.
- (c) It has good drainage properties.
- (d) Sand ballast produces a silent track.

Disadvantages

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

(iv) Ashes Or Cinders:

These are waste products obtained from steam locomotives.

Advantages

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

Disadvantages

- (a) It is very soft and gets crumbled to powder under heavy loads.
- (b) It has got corrosive quality and corrode steel sleepers and foot of the rails.
- (v) Kankar: It is natural material in the form of nodules from which lime is prepared.

Advantages

- (a) It is cheaper.

(b) It has good drainage property.

Disadvantages

(a) It is soft and crumbles to powder under traffic load.

(b) The track laid on kankar ballast are difficult to maintain.

(c) It has corrosive quality.

(vi) 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

(a) It is easily available in most parts of India.

(b) It has good drainage properties.

(c) It is used as blanket for new embankment.

Disadvantages

(a) It is soft and easily crumbles to powder under heavy loads.

(b) Maintenance of track laid on moorum ballast is very difficult.

(vii) Blast Furnance 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

(a) It is a cheap material.

(b) It has good drainage properties.

(c) It is a strong material.

(d) It holds the track in correct alignment and gradient.

Disadvantages

(a) It is not available in large quantity.

(b) Spreading of this material on the formation is difficult.

(c) Maintenance of track laid on slag ballast is difficult.

(iv) 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

(a) It is a cheap material.

(b) It prevents growth of vegetation.

(c) It has good drainage properties.

Disadvantages

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

(ix) 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

Fixtures and fastenings are fittings requires 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:

- (i) To join the rails end to end to form full length of track.
- (ii) To fix the rails to sleepers.
- (iii) To maintain the correct alignment of the track.
- (iv) To provide proper expansion gap between rails.
- (v) To maintain the required tilt of rails.
- (vi) To set the points and crossings in proper position.

TYPES OF FIXTURES AND FASTENING

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, as shown in Fig.7.1. each fish plate is 457 mm long and provided with four holes 32 mm 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.

REQUIREMENTS OF FISH PLATES

- (i) They should hold the adjoining ends of rails in correct horizontal and vertical plane.
- (ii) They should allow free longitudinal movements of rails due to temperature variation.
- (iii) They should be able to resist all types of wear.
- (iv) They should be able to bear the vertical and lateral stresses which come at joints without any distortion.
- (v) They should allow easy renewal and replacement of rails in case of wear and damage.

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.

ADVANTAGES

Following are the advantages of bearing plates:

- (i) They distribute the loads to wider area and prevent sinking of the rail to the sleeper.
- (ii) They avoid adzing of sleepers.
- (iii) They enable the spikes to remain tight and require less maintenance.
- (iv) Bearing plates prevent the widening of gauge on curves.
- (v) Bearing plates increase the overall stability of the track.
- (vi) They prevent the destruction of the sleeper due to rubbing action of the rail.

DISADVANTAGES

Following are the disadvantages of bearing plates:

- (i) When the bearing plates become loose due to settlement of ballast,

moisture is likely to enter between the sleepers and plates, causing sleepers to wear.

- (ii) When any spike is damaged and it is required to be redriven at another

place, all other spikes of the bearing plates have to be removed, which will reduce the holding power of the 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 and 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.

REQUIREMENTS OS A GOOD SPIKE

- (i) It should be easy in fixing or removing from the sleepers.
- (ii) It should hold the rails and bearing plates in proper position.
- (iii) It should be cheap.
- (iv) It should require minimum maintenance.
- (v) It should not come out of the sleepers under vibrations.

BOLTS

Different types of bolts used in Indian Railway are described below.

FISH 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

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

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

- (i) wooden keys
- (ii) 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.