Railway Track (Permanent Way)

The track or permanent way is the railroad on which trains run. It consists of two parallel rails fastened to sleepers with a specified distance between them.

The sleepers are embedded in a layer of ballast of specified thickness spread over level ground known as *formation*. The ballast provides a uniform level surface and drainage, and transfers the load to a larger area of the formation. The rails are joined in series by fish plates and bolts and these are fastened to the sleepers with various types of fittings. The sleepers are spaced at a specified distance and are held in position by the ballast. The layer of ballast rests on the prepared subgrade called the formation.

Each component of the track has a specific function to perform. The rails act as girders to transmit the wheel load of trains to the sleepers. The sleepers hold the rails in their proper positions, provide a correct gauge with the help of fittings and fastenings, and transfer the load to the ballast. The ballast distribute the load over the formation and hold the sleepers in position. The formation takes the total load of the track as well as of the trains moving on it.

The permanent way or track, therefore, consists of the rails, sleepers, fittings and fastenings, the ballast, and the formation as shown in Fig. 2.1.

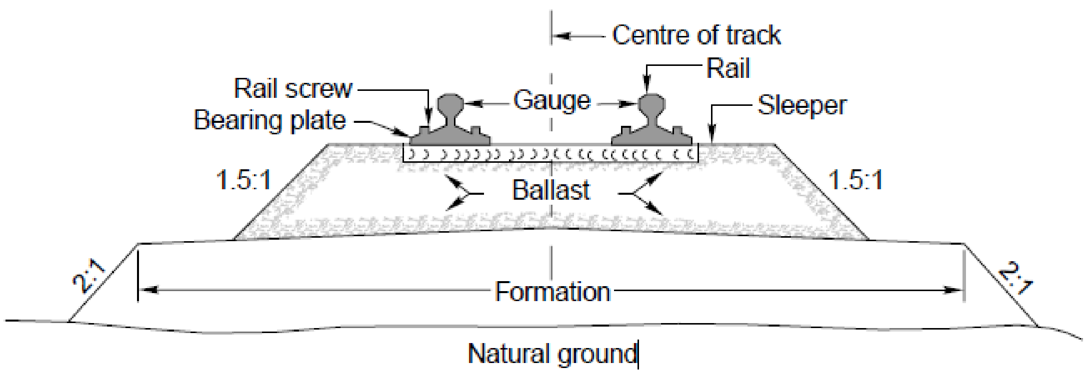


Fig. 2.1 Various components of a track

Requirements of a Good Track

A permanent way or track should provide a comfortable and safe ride at the maximum permissible speed with minimum maintenance cost. To achieve these objectives, a sound permanent way should have the following characteristics.

(a) The gauge should be correct and uniform.

(b) The rails should have perfect cross levels. In curves, the outer rail should have a proper superelevation to take into account the centrifugal force.

(c) The alignment should be straight and free of kinks. In the case of curves, a proper transition should be provided between the straight track and the curve.

(d) The gradient should be uniform and as gentle as possible. The change of gradient should be followed by a proper vertical curve to provide a smooth ride.

(e) The track should be resilient and elastic in order to absorb the shocks and vibrations of running trains.

(f) The track should have a good drainage system so that the stability of the track is not affected by waterlogging.

(g) The track should have good lateral strength so that it can maintain its stability despite variations in temperature and other such factors.

(h) There should be provisions for easy replacement and renewal of the various track components.

(i) The track should have such a structure that not only is its initial cost low, but also its maintenance cost is minimum.

1- 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 are similar to steel girders. These are provided to perform the following functions in a track.

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

(b) 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 tire and a metaled road.

(c) Rails serve as a lateral guide for the wheels.

(d) 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.

(e) Rails carry out the function of transmitting the load to a large area of the formation through sleepers and the ballast.

Chemical Composition of Rails

To meet the above functions, Rails are made of steel and the basic element in steel is iron. With iron are combined small quantities of carbon, manganese, silicon and less desirable sulfur and phosphors.

The basic requirement of rail steel is that it should be hard, wear resistant and crack resistant. This is achieved by steel composition and cooling of the hot rails.

- These properties of steel are achieved through control of carbon (C) and manganese (Mn) contents.
- Silicon its high effinity for oxygen aids in remoning gases during the pouring and rolling processes.
- Phosphors : makes steel brittle (sudden failure) and likely to break under impact.

- Sulfur : causes breaks during the rolling process.

a- For Ordinary Rails. High carbon steel with following composition is used:

Carbon (C)	0.55 to 0.68 percent
Manganese (Mn)	0.65 to 0.90 percent
Silicon (Si)	0.05 to 0.30 percent
Sulphur (S)	0.05 percent or below
Phosphorus (P)	0.06 percent or below

b- For Rails on Points and Crossings. Medium carbon steel with following composition is used:

Carbon (C)	0.50 to 0.60 percent
Manganese (Mn)	0.95 to 1.25 percent
Silicon (Si)	0.05 to 0.20 percent
Sulphur (S)	0.06 percent or below
Phosphorus (P)	0.06 percent or below

Grade	*C*	*Mn*	*Si*	*S (max.)*	*P (max.)*	*Al (max.)*	*Liquid hydrogen*
880	0.6–0.8	0.8–1.3	1.3–0.5	0.035*	0.035*	0.02	3.00

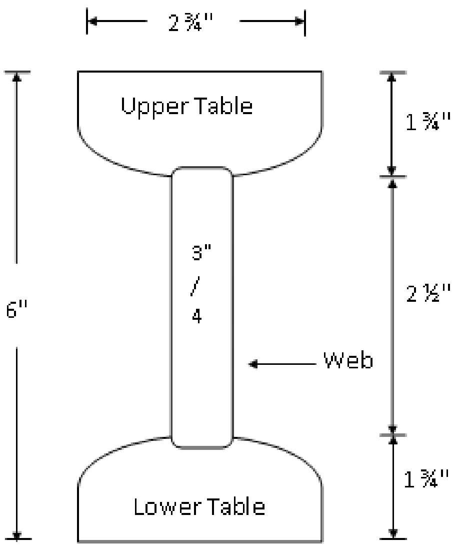
* The maximum value for finishing is 0.040.

Types of Rails

Rails can be divided in three types:

1. Double Headed Rails
2. Bull Headed Rails
3. Flat Footed Rails

1. Double Headed Rails



These rails indicate the early stage of development and made of an I or dumb-bell section. It essentially consists of three parts,

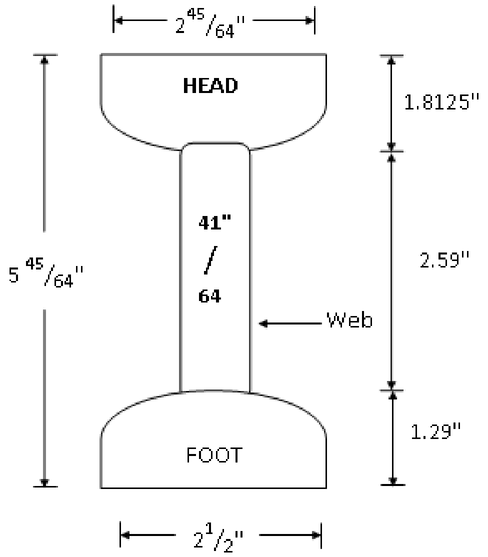
- Upper Table
- Web
- Lower Table

Both the upper and lower tables were identical and they were introduced with the hope of doubling the life of rails. When the upper table is worn out then the rails can be placed upside down reversed on the chair and so the lower table can be brought into use. But this idea soon turned out to be wrong because due to continuous contract of lower table with the chair made the surface of lower table rough and hence the smooth running of the train was impossible. Therefore, this type of rail is practically out of use. Nowadays, these rails vary in lengths from 20 – 24. A 100 lb double headed rail is shown in the figure.

2. Bull Headed Rails

This type of rail also consists of three parts,

- The Head
- The Web
- The Foot



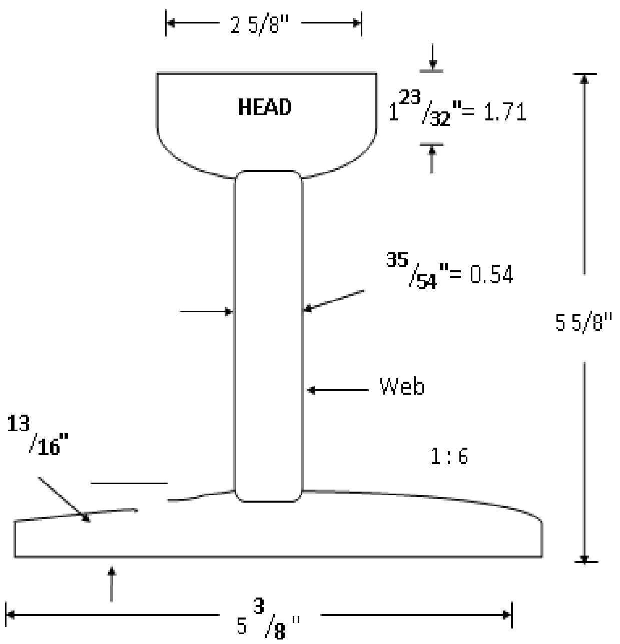
These rails were made of steel. The head is of larger size than foot and the foot is designed only to hold up properly the wooden keys with which rails are secured. Thus, the foot is designed only to furnish necessary strength and stiffness to rails. Two cast iron chairs are required per each sleeper when these rails are adopted. Their weight ranges from 85lb to 95lb and their length is up to 60 ft.

3. Flat Footed Rails

These rails were first of all invented by Charles Vignoles in 1836 and hence these rails are also called vignole's, rails with an inverted T-type cross section. It consist of three parts

- The Head
- The Web
- The Foot

The foot is spread out to form a base.



This form of rail has become so much popular that about 90% of railway tracks in the world are laid with this form of rails.

Flat footed rails has the following advantages

1. They do not need any chair and can be directly spiked or keyed to the sleepers. Thus they are economical.
2. They are much stiffer both vertically and laterally. The lateral stiffness is important for curves.
3. They are less liable to develop kinks and maintain a more regular top surface than bull headed rails.
4. They are cheaper than bull headed rails.
5. The loads from wheels of trains are distributed over larger area of sleepers which results in greater track stability, longer life of rails and sleepers, reduced maintenance, costs, less rail failure and few interruptions to traffic.

Requirements for an Ideal Rail Section

The requirements for an ideal rail section are as follows.

(a) The rail should have the most economical section consistent with strength, stiffness, and durability.

(b) The center 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.

(c) 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 requirements, as well as the main considerations, for the design of these rail components are as follows.

Head**:** 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.

Web: The web should be sufficiently thick so as to withstand the stresses arising due to the loads bone by it, after allowing for normal corrosion.

Foot: 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: 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: The height of the rail should be adequate so that the rail has sufficient vertical stiffness and strength as a beam.

Standard Rail Section

The rail is designated by its weight per unit length. The weight of a rail per length is an important factor in determining rails strength and hence axle loads and speeds. In FPS units, it is the weight in lbs per yard and in metric units it is in kg per meter, the pounds-per-yard figure is almost exactly double the kilograms-per-meter figure. A 52 MR rail denotes that it has a weight of 52 kg per meter and a 132 R rail means a rail of 132 pounds per yard.

The weight of a rail and its section is decided after considerations such as the following:

(a) Maximum permissible speed of train.

(b) The gauge of the track.

(c) The axle load and the nature of traffic.

(d) Type of rails, whether D.H. or B.H. or F.F. rails.

(d) Type and spacing of sleepers (sleeper density).

(e) Maximum permissible wear on the top of rails (5 percent of the weight of the rail is allowed).

The standard rail sections in use on Iraqi Railways are 60 kg

60 kg (UIC)	60.4 kg/m
Area	76.6 cm^2
Height	172mm
Base width	150 mm
Bed width	72 mm
Moment of inertia	3055 cm^4

UIC—International Union of Railways

Weight of rails

Though the weights of a rail and its section depend upon various considerations, the heaviest axle load that the rail has to carry plays the most important role. The following is the thumb rule for defining the maximum axle load with relation to the rail section:

Maximum axle load = 560 × sectional weight of rail (in lbs per yard or kg per meter).

For rails of 90 lbs per yard,

Maximum axle load = 560 × 90 lbs = 50,400 lbs or 22.5 t

For rails of 52 kg per m,

Maximum axle load = 560 × 52 kg = 29.12 t

Length of rails

Theoretically, the longer the rail, the lesser 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. The length of a rail is, however, restricted due to the following factors.

(a) Lack of facilities for transport of longer rails, particularly on curves.

(b) Difficulties in manufacturing very long rails.

(c) Difficulties in acquiring bigger expansion joints for long rails.

(d) Heavy internal thermal stresses in long rails.

Jointed rails shall not be less than 15 m long (the preferred length being 36 m different in transportation). The other alternative to increase the length of rails, is to weld the rail at the site as it eliminates the difficulty of transportation, handling and lifting. Due to development of technologies and welding process, it has Short Welded Rail (SWR), Long Welded Rail (LWR) for a length up to 200-300 m and Continuous Welded Rail (CWR) up to a length of 3-4 kms.

Rail Wear

Due to the passage of moving loads and friction between the rail and the wheel, the rail head gets worn out in the course of service. The impact of moving loads, the effect of the forces of acceleration, deceleration, and braking of wheels, the abrasion due to rail–wheel interaction, the effects of weather conditions such as changes in temperature, snow, and rains, the presence of materials such as sand, and such allied factors cause considerable wear of the vertical and lateral planes of the rail head.

Lateral wear occurs more on curves because of the lateral thrust exerted on the outer rail by centrifugal force. A lot of the metal of the rail head gets worn out, causing the weight of the rail to decrease. This loss of weight of the rail section should not be such that the stresses exceed their permissible values. When such a stage is reached, rail renewal is called for.

Type of Wear on Rails

A rail may face wear and tear in the following positions:

(a) on top of the rail head (*vertical wear*)

(b) on the sides of the rail head (*lateral wear*)

(c) on the ends of the rail (*battering of rail ends*)

Wear is more prominent at some special locations of the track. These locations are normally the following:

(a) on sharp curves, due to centrifugal forces

(b) on steep gradients, due to the extra force applied by the engine

(c) on approaches to railway stations, possibly due to acceleration and deceleration

(d) in tunnels and coastal areas, due to humidity and weather effects

Measurement of Wear

Wear on rails can be measured using any of the following methods.

(a) By weighing the rail.

(b) By using special instruments designed to measure the profile of the rail and record it simultaneously on graph paper.

Methods to Reduce Wear

Based on field experience, some of the methods adopted to reduce vertical wear and lateral wear on straight paths and curves are indicated below.

(a) Better maintenance of the track to ensure good packing as well as proper alignment and use of the correct gauge

(b) Reduction in the number of joints by welding

(c) Use of heavier and higher UTS rails, which are more wear resistant

(d) Use of bearing plates and proper adzing in case of wooden sleepers

(e) Lubricating the gauge face of the outer rail in case of curves

(f) Providing check rails in the case of sharp curves

(g) Interchanging the inner and outer rails

(h) Changing the rail by carrying out track renewal