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Unit-1Railways:

Introduction, Tractive resistances & Permanent way: Principles of Transportation, transportation by Roads, railways, Airways, Waterways, their importance and limitations, Route surveys and alignment, railway track, development and gauges, Hauling capacity and tractive effort.

i) Rails: types, welding of rails, wear and tear of rails, rail creep.

ii) Sleepers: types and comparison, requirement of a good sleeper, sleeper density.

iii) Rail fastenings: types, Fish plates, fish bolts, spikes, bearing plates, chain keys, check and guard rails.

iv) Ballast: Requirement of good ballast, various materials used as ballast, quantity of ballast, different methods of plate laying, material trains, calculation of materials required, relaying of track.

INTRODUCTION

One of the most important modes of transportation is the railway. With the development of civilization mankind developed various modes of transport for carrying people and goods from one place to another. Of these modes, the railway network of any country, especially of a developing country like India, has come to be considered as the most important asset in achieving all-round progress- economic, social, cultural, industrial, commercial and political. Various forces offer resistance to the movement of a train on the track. These resistances may be the result of movement of the various parts of the locomotives as well as the friction between them, the irregularities in the track profile, or the atmospheric resistance to a train moving at great speed. The tractive power of a locomotive should be adequate enough to overcome these resistances and haul the train at a specified speed.

RESISTANCE DUE TO FRICTION-Resistance due to friction is the resistance offered by the friction between the internal parts of locomotives and wagons as well as between the metal surface of the rail and the wheel to a train moving at a constant speed. This resistance is independent of speed and can be further broken down into the following parts.

Journal friction-This is dependent on the type of bearing, the lubricant used, the temperature and condition of the bearing, etc. In the case of roll bearings, it varies from 0.5 to 1.0 kg per tones. Internal resistance-This resistance is consequential to the movement of the various parts of the locomotive and wagons. Rolling resistance-This occurs due to rail-wheel interaction on account of the movement of steel wheels on a steel rail. The total frictional resistance is given by the empirical formula $R1= 0.0016\ W$ Where R1 is the frictional resistance independent of speed and W is the weight of the train in tones.

RESISTANCE DUE TO WAVE ACTION-When a train moves with speed a certain resistance develops due to the wave action in the rail. Similarly, track irregularities such as longitudinal unevenness and differences in cross levels also offer resistance to a moving train. Such resistances are different for different speeds. There is no * Under revision method for the precise calculation of these resistances but the following formula has been evolved based on experience:

$R2 = 0.00008\ WV$ Where R2 is the resistance (in tones) due to wave action and track irregularities on account of the speed of the train, W is the weight of the train in tones, and V is the speed of the train in kmph.

RESISTANCE DUE TO WIND-When a vehicle moves with speed, a certain resistance develops, as the

vehicle has to move forward against the wind. Wind resistance consists of side resistance, head resistance, and tail resistance, but its exact magnitude depends upon the size and shape of the vehicle, its speed, and the wind direction as well as its velocity. Wind resistance depends upon the exposed area of the vehicle and the velocity and direction of the wind. In Fig. below, V is the velocity of wind at an angle θ. The horizontal component of wind, V COSθ, opposes the movement of the train. Wind normally exerts maximum pressure when it acts at an angle of 60° to the direction of movement of the train. Wind resistance can be obtained by the following formula:

R3 =$0.000017AV^2$ Where A is the exposed area of vehicle (m^2) and V is the velocity of wind (k-mph).

R3 = $0.0000006 W V^2$

Where R3 is the wind resistance in tones, Vis the velocity of the train in km per hour, and W is the weight of the train in tones.

Track or permanent way

Track or permanent way is the single costliest asset of Indian Railways. It consists of rails, sleepers, fittings and fastenings, ballast, and formation.

Traction

The traction mix has significantly changed in the last two decades and Railways have been progressively switching over to diesel and electric traction. Though Steam locomotion involves the least initial costs, it is technologically inferior to Diesel and electric traction in many respects. On the other hand, diesel and electric Locomotives have superior performance capabilities, the electric locomotive being the more powerful one of the two. Electric traction is also the most capital intensive and, therefore, requires a certain minimum level of traffic density for its economic use. In broad terms, the traction policy on Indian Railways envisages the extension of the electrification of high-density routes as dictated by economic and resource considerations and the dieselization of the remaining services.

GAUGE

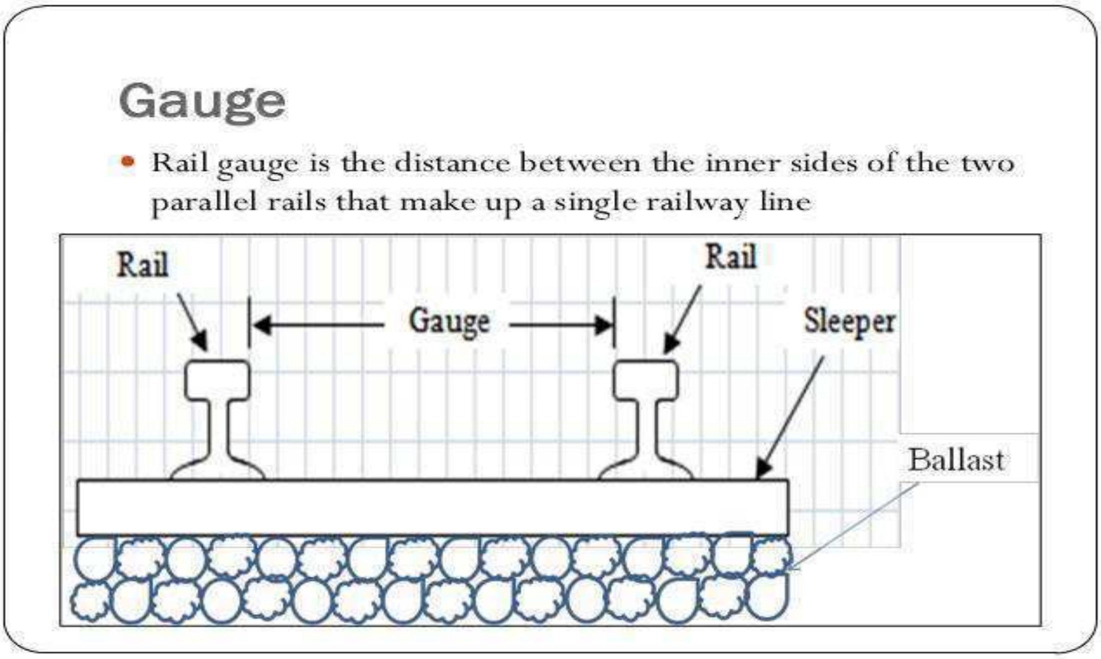
Gauge is defined as the minimum distance between two rails. Indian Railways follows this standard practice and the gauge is measured as the clear minimum distance between the running faces of the two rails.

Name of gauge Width (mm) Width (feet) Route % of route

Broad gauge (BG) 1676

Meter gauge (MG) 1000

Narrow gauge (NG) 762



Alignment of railway line-

Alignment of railway line refers to the direction and position given to the center line of the railway track on the ground in the horizontal and vertical planes. Horizontal alignment means the direction of the railway track in the plan including the straight path and the curves it follows. Vertical alignment means the direction it follows in a vertical plane including the level track, gradients, and vertical curves.

HAULING POWER OF A LOCOMOTIVE-

Hauling power of a locomotive depends upon the weight exerted on the driving s and the friction between the driving wheel and the rail. The coefficient of friction depends upon the speed of the locomotive and the condition of the rail surface. The higher the speed of the locomotive, the lower will be the coefficient of friction, which is about 0.1 for high speeds and 0.2 for low speeds. The condition of the rail surface, whether wet or dry, smooth or rough, etc., also plays an important role in deciding the value of the coefficient of function. If the surface is very smooth, the coefficient of friction will be very low.

Hauling power = number of pairs of driving wheels x weight exerted on each driving axle X coefficient of friction.

Thus, for a locomotive with three pairs of driving wheels, an axle load of 20 tones, and a coefficient of friction equal to 0.2, the hauling power will be equal to 3 x 20 x 0.2 tones, i.e., 12 tones.

Importance of Good Alignment-

A new railway line should be aligned carefully after proper considerations, as improper alignment may ultimately prove to be more costly and may not be able to fulfill the desired objectives. Railway line constructions are capital-intensive projects, once constructed, it is very difficult to change the alignment of a railway line because of the costly structures involved, difficulty in getting additional land for the new alignment, and such other considerations.

Basic Requirements of an Ideal Alignment-

The ideal alignment of a railway line should meet the following requirements.

Purpose of the New Railway Line

The alignment of a new railway line should serve the basic purpose for which the railway line is being

constructed. As brought out earlier, the purpose may include strategic considerations, political considerations, developing of backward areas, connecting new trade centers, and shortening existing rail lines.

Integrated Development

The new railway line should fit in with the general planning and form a part of the integrated development of the country.

Economic Considerations-

The construction of the railway line should be as economical as possible. The following aspects require special attention. Shortest route it is desirable to have the shortest and most direct route between the connecting points. The shorter the length of the railway line, the lower the cost of its construction, maintenance, and operation. There can, however, be other practical considerations that can lead to deviation from the shortest route. Construction and maintenance cost the alignment of the line should be so chosen that the construction cost is minimum. This can be achieved by a balanced cut and fill of earthwork, minimizing rock cutting and drainage crossings by locating the alignment on watershed lines, and such other technical considerations. Maintenance costs can be reduced by avoiding steep gradients and sharp curves, which cause heavy wear and tear of rails and rolling stock.Minimum operational expenses the alignment should be such that the operational or transportation expenses are minimum. This can be done by maximizing the haulage of goods with the given power of the locomotive and traction mix. This can be achieved by providing easy gradients, avoiding sharp curves, and adopting a direct route.

Maximum Safety and Comfort-

The alignment should be such that it provides maximum safety and comfort to the travelling public. This can be achieved by designing curves with proper transition lengths, providing vertical curves for gradients, and incorporating other such technical features.

Aesthetic Considerations-

While deciding the alignment, aesthetic aspects should also be given due weightage. A journey by rail should be visually pleasing. This can be done by avoiding views of borrow pits and passing the alignment through natural and beautiful surroundings with scenic beauty.

Selection of a Good Alignment

Normally, a direct straight route connecting two points is the shortest and most economical route for a railway line, but there are practical problems and other compulsions which necessitate deviation from this route. The various factors involved is the selection of a good alignment for a railway line are given below.

Choice of Gauge-

The gauge can be a BG (1676 mm), an MG (1000 mm), or even an NG (762 mm).

Obligatory or Controlling Points

These are the points through which the railway line must pass due to political, strategic, and commercial reasons as well as due to technical considerations. The following are obligatory or controlling points. Important cities and towns these are mostly intermediate important towns, cities, or places which of commercial, strategic, or political importance. Major bridge sites and river crossings The construction of major bridges for large rivers is very expensive and suitable bridge sites become obligatory points for a good alignment. Existing passes and saddles in hilly terrain Existing passes and saddles should be identified for crossing a hilly terrain in order to avoid deep cuttings and high banks.Sites for tunnels The option of a tunnel in place of a deep cut in a hilly terrain is better from the economical viewpoint. The exact site of such a tunnel becomes an obligatory point.

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 super elevation 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 water logging.

(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.

Introduction to 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. Standard rail sections, their specifications, and various types of rail defects are discussed in this chapter.

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.

Types of Rails

A flat-footed rail, also called a Vignola rail with an inverted T-type cross section of inverted T- type was, therefore, developed, which could be fixed directly to the sleepers with the help of spikes.

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:

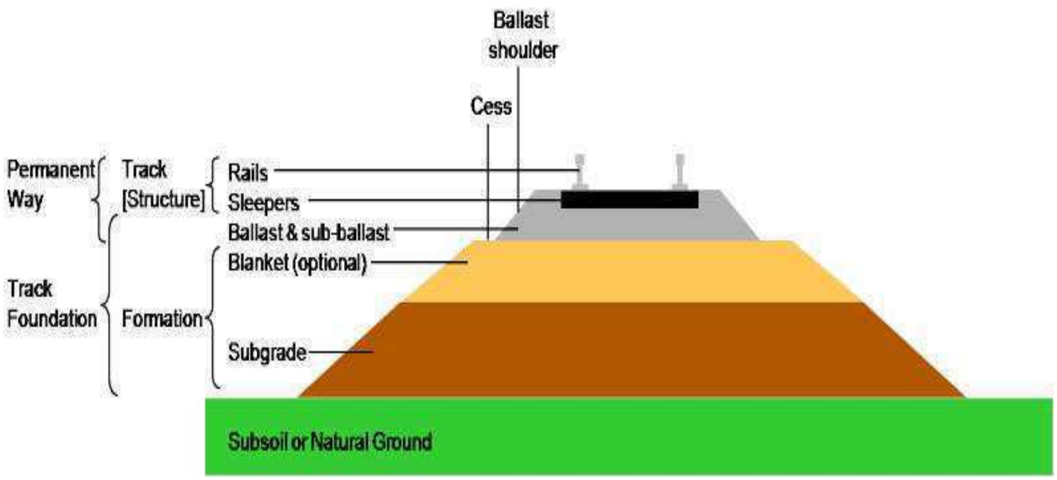
Maximum axle load = 560 × sectional weight of rail in lbs. per yard or kg per meter

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



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, the standard of maintenance of the track, and such allied factors cause considerable wear and tear 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 Rails stresses exceed their permissible values. When such a stage is reached, rail renewal is called for.

In addition, the rail head should not wear to such an extent that there is the possibility of a worn flange of the wheel hitting the fish plate.

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)

(a) On the sides of the rail head (lateral wear)

(b) 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 causes of rail failures.

The main causes for the failure of rails are as follows.

Inherent defects in the rail manufacturing defects in the rail, such as faulty chemical composition, harmful segregation, piping, seams, laps, and guide marks. Defects due to fault of the rolling stock and abnormal traffic effects Flat spots in tires, engine burns, skidding of wheels, severe braking, etc. Excessive corrosion of rails Excessive corrosion in the rail generally takes place due to weather conditions, the presence of corrosive salts such as chlorides and constant exposure of the rails to moisture and humidity in locations near water columns, ash pits, tunnels, etc. Corrosion normally leads to the development of cracks in regions with a high concentration of stresses. Badly maintained joints Poor maintenance of joints such as improper packing of joint sleepers and loose fittings.

Defects in welding of joints-These defects arise either because of improper composition of the termite weld metal or because of a defective welding technique. Improper maintenance of track Ineffective or careless maintenance of the track or delayed renewal of the track. Derailments Damages caused to the rails during derailment.

- Creep of Rails

Introduction

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 centimeters 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. As the wheels of the train move forward, the depressions also move with them and the previously depressed portion springs back to the original level. This wave motion tends to move the rail forward with the train. The ironing effect of the moving wheels on the wave formed in the rail causes a longitudinal movement of the rail in the direction of traffic resulting in the creep of the rail.

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 of wheels passing overt 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 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.

- **Effects of Creep**

The following are the common effects of creep.

Sleepers out of square the sleepers move out of their position as a result of creep and become out of square. This in turn affects the gauge and alignment of the track, which finally results in unpleasant rides. Disturbance in gaps get disturbed Due to creep, the expansion gaps widen at some places and close at others. This results in the joints getting jammed. Undue stresses are created in the fish plates and bolts, which affects the smooth working of the switch expansion joints in the case of long welded rails. Distortion of points and crossings Due to excessive creep, it becomes difficult to maintain the correct gauge and alignment of the rails at points and crossings. Difficulty in changing rails If, due to operational reasons, it is required that the rail be changed, the same becomes difficult as the new rail is found to be either too short or too long because of creep.

- **Effect on interlocking**

The interlocking mechanism of the points and crossings gets disturbed by creep. Possible buckling of track if the creep is excessive and there is negligence in the maintenance of the track, the possibility of buckling of the track cannot be ruled out.

- **Sleepers**

Introduction

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 and Requirements 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.

Apart from performing these functions the ideal sleeper should normally fulfill the following requirements.

(a) The initial as well as maintenance cost should be minimum.
(b) The weight of the sleeper should be moderate so that it is convenient to handle.
(c) The designs of the sleeper and the fastenings should be such that it is possible to fix and remove the rails easily.
(d) The sleeper should have sufficient bearing area so that the ballast under it is not crushed.
(e) The sleeper should be such that it is possible to maintain and adjust the gauge properly.
(f) The material of the sleeper and its design should be such that it does not break or get damaged during packing.
(g) The design of the sleeper should be such that it is possible to have track Circuiting.

- SLEEPER DENSITY AND SPACING OF SLEEPERS

Sleeper density is the number of sleepers per rail length. It is specified as M + x or N + x, where M or N is the length of the rail in meters and x is a number that varies according to factors such as

(a) Axle load and speed,
(b) Type and section of rails,
(c) Type and strength of the sleepers,
(d) Type of ballast and ballast cushion, and
(e) Nature of formation. If the sleeper density is M + 7 on a broad gauge route and the length of the rail is 13 m, it means that 13 + 7 = 20 sleepers will be used per rail on that route.

The number of sleepers in a track can also be specified by indicating the number of sleepers per kilometer of the track. For example, 1540 sleepers/km. This specification becomes more relevant particularly in cases where rails are welded and the length of the rail does not have much bearing on the number of sleepers required. This system of specifying the number of sleepers per kilometer exists in many foreign countries and is now being adopted by Indian Railways as well. The spacing of sleepers is fixed depending upon the sleeper density. Spacing is not kept uniform throughout the rail length. It is closer near the joints because of the weakness of the joints and impact of moving loads on them. There is, however, a limitation to the close spacing of the sleepers, as enough space is required for working the beaters that are used to pack the joint sleepers.

Types of Sleepers

The sleepers mostly used on Indian Railways are

(h) Wooden sleepers,
(a) Cast iron sleepers,
(b) Steel sleepers, and
(c) 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. The wooden sleeper has the following features. Specifications the size of a wooden sleeper should be economical. It should provide the desired strength to the sleeper as a beam as well as adequate bearing area. The depth of a sleeper governs its stiffness as a beam and its length and width control the necessary bearing area. The bearing length under each rail seat is 92 cm (3 ft.) for a BG wooden sleeper, thereby giving an area of 2325 cm2 under each rail seat.

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
(f) Alignment can be easily corrected
(g) More suitable for modern methods of maintenance
(h) Can be used with or without stone ballast
(i) Can be used on bridges and ash pits also
(j) Can be used for gauntleted track

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
(d) Susceptible to fire hazards
(e) Negligible scrap value

- **Durable and Non-durable Types of Sleepers**

Wooden sleepers may be classified into two categories, durable and non-durable.

- **Durable type**

Durable sleepers do not require any treatment and can be laid directly on the track. The Indian Railway Board has classified particular categories of sleepers as the durable type. These are sleepers produced from timbers such as teak, sal, nahor, rosewood, anjan, kongu, crumbogamkong, vengai, padauk, lakooch, wonta, milla, andcrul.

- **Non-durable type**

Non-durable sleepers require treatment before being put on the track. Non-durable sleepers are made of wood of trees such as chir, deodar, kail, gunjan, and jamun.

- Treated and Untreated Sleepers

Wooden sleepers are also sometimes classified as hard wood and soft wood sleepers depending upon the origin or species of the wood of which these are made. Broadly speaking, timber produced from trees with broad leaves is known as hard wood and that obtained from trees bearing long leaves is considered soft wood. Some of the hard wood varieties also require treatment before being used in the track. As per the recommendations of the committee, the use of the terms 'durable' and 'non-durable' as well as 'hard' and 'soft' should be done away with to avoid confusion.The committee recommended that for simplification and rationalization, wooden sleepers should be classified in two categories:
(a) 'U' or Untreated sleepers comprising of all the sleepers made of wood from naturally durable species.
(b) 'T' or Treated sleepers consisting of the rest of the sleepers

- Seasoning of sleepers

Wooden sleepers are seasoned to reduce the moisture content so that their treatment is effective. The Indian Standard code of practice for preservation of timber lays down that the moisture content in the case of sleepers to be treated by pressure treatment should not be more than 25%. The seasoning of sleepers can be done by any one of the following processes. Artificial seasoning in kiln This is a controlled method of seasoning the timber, normally used in the USA and other advanced countries, under conditions of temperature and relative humidity, which are in the range of natural air seasoning. Bolton or boiling under vacuum process this is a process in which unseasoned wood is treated with hot preservative to remove the moisture content. This is adopted in the Naharkatia depot. Air seasoning This is the method adopted extensively for the seasoning of wooden sleepers in India. The sleepers are stacked in the timber yard and a provision is made for enough space for the circulation of air in between the sleepers.

- Concrete Sleepers

The need for concrete sleepers has been felt mainly due to economic considerations coupled with changing traffic patterns. In the early days of Indian Railways, wood was the only material used for making sleepers in Europe. Even in those days, the occasional shortage of wooden sleepers and their increasing price posed certain problems and this gave a fillip to the quest for an alternative material for sleepers.

- Advantages and disadvantages

Concrete sleepers have the following advantages and disadvantages.

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.
(g) Concrete sleepers can generally be mass produced using local resources.

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.
(e) Concrete sleepers should preferably be maintained by heavy 'on track' Tamper.

Ballast

Introduction

The ballast is a layer of broken stones, gravel, moored, or any other granular
Material placed and packed below and around sleepers for distributing load fromthe sleepers to the formation. It provides drainage as well as longitudinal and lateralstability to the track.

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.

Types of Ballast

The different types of ballast used on Indian Railways are described in the following.

Sand ballast

Sand ballast is used primarily for cast iron (CI) pots. It is also used with wooden and steel trough sleepers in areas where traffic density is very low. Coarse sand is preferred in comparison to fine sand. It has good drainage properties, but has the drawback of blowing off because of being light. It also causes excessive wear of the rail top and the moving parts of the rolling stock.

Morum ballast

The decomposition of lateritic results in the formation of moor. It is red, and sometimes yellow, in color. The moored ballast is normally used as the initial ballast in new constructions and also as sub-ballast. As it prevents water from percolating into the formation, it is also used as a blanketing material for black cotton soil.

Coal ash or cinder

This type of ballast is normally used in yards and sidings or as the initial ballast in new constructions since it is very cheap and easily available. It is harmful for steel sleepers and fittings because of its corrosive action.

Broken stone ballast

This type of ballast is used the most on Indian Railways. A good stone ballast is generally procured from hard stones such as granite, quartzite, and hard trap. The quality of stone should be such that neither is it porous nor does it flake off due to the vagaries of weather. Good quality hard stone is normally used for high-speed tracks. This type of ballast works out to be economical in the long run.

Sizes of Ballast

Previously, 50-mm (2") ballasts were specified for flat bottom sleepers such as concrete and wooden sleepers and 40-mm (1.5") ballasts were specified for metal sleepers such as CST-9 and trough sleepers. Now, to ensure uniformity, (2") ballasts have been adopted universally for all type of sleepers. As far as points and crossings are concerned, these are subjected to heavy blows of moving loads and are maintained to a higher degree of precision. A small sized, 25-mm (1") ballast is, therefore, preferable because of its fineness for slight adjustments, better compaction, and increased frictional area of the ballast.

- **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 be cheap and economical.

Plate Laying methods or Track Linking –

Once the formation is ready, plate laying or track linking is required. It consists of laying rails, sleepers, and fastenings.

The following methodology is adopted for plate laying.

Tram Line Method In this method, a temporary line known as the 'tram line' is laid by the side of the proposed track for taking track materials to the site. This method is useful in flat terrain, where laying

the tram line on natural ground may be comparatively easier. This method is, however, seldom used in practice. A modification of the above method is the side method. This method is used where track and bridge material is carried to the site on trucks on a service road parallel to the track. The material is then unloaded near the work site. This method is used only in cases where comparatively flat gradients are available.

American Method- in the American method, rails and sleepers are first assembled in the base depot and pre-assembled track panels are then taken to the site along with the necessary cranes, etc. The track panels are unloaded at the work site either manually or with the help of cranes and are then laid in the final position. This procedure is used in many developed countries, particularly those where concrete sleepers are laid, since these sleepers are quite heavy and it is not easy to handle them manually.

Telescopic Method- This method is widely used on Indian Railways. In this method, the rails, sleepers, and other fittings are taken to the base depot and unloaded. The track material is then taken to the rail head and the track is linked and packed. The rail head is then advanced up to the extent of laid track. The track material is then taken up to the advanced rail head with the help of a dip lorry and the track is again linked and packed. In this way, the rail head goes on advancing till the full track is linked.

The main operations involved are as follows.

Unloading of materials-The track material is taken to the base depot and unloaded with the help of material gangs. The first base depot is the junction of the existing line and the new line to be constructed. All track material is taken from the base depot with the help of a dip lorry (a special type of trolley) to the rail head. The rail head goes on advancing till the track is sufficiently linked. After that, a subsidiary depot is established at a distance of about 5 km where the track material is taken with the help of a material train. Alternatively, the track material is moved from the base depot with the help of dip lorry only up to a distance of about 2 km and by material train beyond this distance. In the base depot, advance arrangements such as adzing and boring of the sleeper and arrangement of matching materials are made so that the track is linked as soon as possible to the site.

TRACK FITTINGS AND FASTENINGS

INTRODUCTION TO FASTENINGS

The purpose of providing fittings and fastenings in railway tracks is to hold the rails in their proper position in order to ensure the smooth running of trains. These fittings and fastenings are used for joining rails together as well as fixing them to the sleepers, and they serve their purpose so well that the level, alignment, and gauge of the railway track are maintained within permissible limits even during the passage of trains.

Rail-to-Rail Fastenings-

Rail-to-rail fastenings involve the use of fish plates and bolts for joining rails in series. Detailed descriptions of these are given in the following sections.

- Fish Plates

The name 'fish plate' derives from the fish-shaped section of this fitting. The function of a fish plate is to hold two rails together in both the horizontal and vertical planes. Fish plates are manufactured using a special type of steel (Indian Railways specification T-1/57) with composition given below:
Carbon: 0.30–0.42%
Manganese: not more than 0.6%
Silicon: not more than 0.15%
Sulfur and phosphorous: not more than 0.06%.

- Dog Spikes

This fastening is named dog spike because the head of this spike looks like the ear of a dog. Dog spikes are used for fixing rails to wooden sleepers. The number of dog spikes normally used is as follows:

- Location Number of dog spikes

On straight track 2 (1 on either side and duly staggered)
On curved track 3 (2 outside and 1 inside)
Joint sleepers, bridges 4 (2 outside and 2 inside)

- Round Spikes

Round spikes (Fig. 10.5) are used along with anti-creep bearing plates for fixing rails to sleepers. These are also used for fixing assemblies of switches onto wooden sleepers. The round spike has a round section of a diameter of 18 mm, and its length depends upon the purpose it serves. Round spikes have become obsolete now.

- Screw Spikes

Indian Railways has developed screw spikes with diameters of 20 mm and 22 mm to be used on high-speed, main, and trunk routes in order to increase the lifespan of wooden sleepers. Screw spikes with a diameter of 20 mm are called 'plate screws' and are used in place of round spikes for fixing rails to sleepers with the help of anti-creep bearing plates while screw spikes with a diameter of 22 mm are called 'rail screws' and are used to directly fasten the rails to the sleepers with or without the use of bearing plates. They are also used on bridges and platform lines. Plate and rail screws should be preferred to round and dog spike in order to conserve the life of wooden sleepers.

- Bearing Plates

Bearing plates are used for fixing wooden sleepers to rails. The different types of bearing plates in use on Indian Railways are described below. Mild steel canted bearing plates Mild steel canted bearing plates are used on all joints and curves to provide a better bearing area to the rails. They have a cant of 1 in 20 and a groove in the center to prevent rocking. Mild steel (MS) canted bearing plates with only round holes are sanctioned for use on the Railways. The normal size of this kind of bearing plate is 260 mm × 220 mm × 18 mm for 52 kg and 90 R rail

- Flat MS bearing plates

Flat MS bearing plates are used at points and crossings in the lead portion of a turnout. No cant is

provided in these bearing plates. The size of this bearing plate is 260 mm × 220 mm × 19 mm for 52 kg and 90 R rails Cast iron anticreep bearing plate's Cast iron (CI) anticreep bearing plates are provided with wooden sleepers at locations where the rails are likely to develop creep. These bearing plates have a cant of 1 in 20 and can be fixed using normal round spikes. The size of this bearing plate is 285 mm × 205 mm for BG tracks Special CI bearing plates for BH rails Special cast iron bearing plates are used for fixing bull headed (BH) rails. The rail is held in position with the help of a spring key.