Unit 4 Railway Engineering

Role of Indian railways

1. It helps integrate fragmented markets and thereby stimulate the emergence of a market economy.
2. It connects industrial production centres with markets as well as sources of raw material thereby facilitates industrial development.
3. It links agricultural production centres with distant markets as well as sources of inputs, thereby promoting rapid agricultural growth.
4. It provides rapid, reliable, and cost-effective bulk transportation to the energy sector. for example, to move coal from the coalfield to power plants and petroleum products from refirm..z to consumption centres.
5. It links people with places, enabling large-scale, rapid, and low-cost movement of people across the length and breadth of the country.
6. In the process, Indian Railways has become a symbol of national integration and a Strategic instrument for enhancing our defence preparedness.

General features of Indian railways.

Track

Track or permanent way is the single costliest asset of Indian Railways. It consists of rail sleepers, fittings and fastenings, ballast, and formation.
As on 31.03.2016, the Indian Railways had
i) Route length - 66,687 km
ii) Running Track length - 92.081 km
iii) Total Trackage - 1.19.630 km

Concrete Sleepers

Concrete sleepers are economical and functionally best suited for high speed and heavy density traffic Adequate capacity has been developed for production of concrete sleepers to meet the present requirement of IR and only concrete sleepers are being used for all renewals, new lines, doubling, gauge conversion etc.

Traction

Electric and Diesel traction constitute the principal modes of traction on Indian railways.The traction mix has significantly changed in the last two decades and Railways have been progressively switching over to diesel and electric traction. Diesel and electric locomotives have superior performance capabilities, the electric locomotive being the more powerful.

Electrification

With a view to reduce the Nation's dependence on imported petroleum based energy and to enhance energy security of the Country, as well as to make the Railway System more eco-friendly and modernized, Indian Railways have been progressively electrifying its rail routes.
Upto March 2016, 23,555 Route kilometers which is 35.32% of the total Railway network has been electrified. On this electrified route 64.80% of freight traffic & 51.30% of Passenger traffic hauled with fuel cost on electric traction being merely 38.70% of the total traction fuel cost on dian Railways.

Gauge

Gauge of a railway track is defined as the clear minimum perpendicular distance between the inner faces of two rails.

Different gauges on Indian Railway

In India, the following gauges are being used depending upon the topography of the area and other factors such as cost of construction, volume and nature of traffic, development of the area, and speed of the train desired ;
Broad gauge (B.G.)
Metre gauge (M.G.)
Narrow gauge (N.G.)

Broad Gauge

It means that the clear horizontal distance between the inner faces of two parallel rails forming a track is 1676 mm i.e. 1.676 m.
It is also known as the Standard gauge of India. This type of gauge is recommended when sufficient funds are available and the chances of better revenue are bright. It is generally used for plain areas having more density of population and better prospects of development.

Metre Gauge

It means that the clear distance between the inner faces of two parallel rails forming a is 1000 mm or 1 m. This type of gauge is recommended where chances of income are less and funds are insufficient.

Narrow Gauge

It means that the clear distance between the inner faces of two parallel rails forming a track is either 762 mm or 610 mm. If it is 610 mm, then the gauge is referred to as a feeder gauge. This type of gauge is provided in hilly areas and areas having less population. In hilly areas, there will be more sharp curves and steep gradients and as such broad gauge cannot be constructed Moreover, the chances of revenue are not bright. Feeder gauge is generally provided for supplying the raw material, to big government and private factories such as sugar factories• steel plants, etc. This type of gauge is also used for developing poor areas.

Uni-gauge policy and its benefits.

1. The uniformity of gauges results in the following advantages
2. It will avoid delay and hardship to passengers for changing from BG to M.G, or N,G,
3. As the transhipping is not required, there is no breakage of goods.
4. It will save labour expenses for unloading and then again loading the luggage from one train to another.
5. Possibility of thefts and misplacement, while changing from one vehicle to another, is eliminated.
6. Large sheds to store goods are not required.
7. Labour strikes, etc. do not affect the service and operation of trains.
8. The uni gauge system provides alternate routes for free movement of traffic, resulting in reduced pressure on the track.
9. Locomotives can be effectively used on all the tracks if a uniform type of gauge is adopted.
10. Duplication of equipment such as platforms, sanitary arrangements, clocks, etc. is avoided.
11. This saves a lot of extra expenditure.
12. Due to the unigauge system the development of all areas will be uniform, resulting in balanced economic growth.
13. During military movement, no time is wasted in changing personnel and equipment from one vehicle to another if the gauge is uniform.

Permanent Way

The railway track of permanent nature which handles the normal commercial traffic regularly is called a permanent way. The purpose or use of a permanent is to provide a permanent facility for safe quick movements of normal commercial traffic between the starting and destination stations.

Various component of permanent way are:

1. Rails
2. Sleepers
3. Ballasts
4. Fittings and fastenings
5. Formations

Functions of each components

Rails

Rails are steel girders over which the train moves and transmit the wheel loads of trains to the sleepers belows.

Sleepers

The sleepers hold the rails in proper positions and provide a correct gauge with help of the fitting and fastenings and transfer the train load to a larger area of formation below.

Ballast

The ballast distributes the load over the formation and holds the sleepers in position and provides a uniform level surface. They also provide drainage to track and transfer the train load to a larger area of formation below.

Requirement of an ideal permanent way

1. The gauge should be correct and uniform
2. Both rails should be at the same level
3. Curves should be properly designed
4. The alignment should be short easy safe and economical.
5. The gradient should be even and uniform throughout the length of the track
6. The track should be resilient and elastic in order to absorb shocks and vibration of running
7. The permanent way should be sufficiently strong against lateral forces.
8. The design of the permanent way should be such that the load of trains is uniformly distributed on both the rails.

Factors to be considered while selecting a good alignment

1. Length of track should be as short as possible.
2. The initial construction cost should be minimum. This can be achieved by avoiding loose earth slopes, rock cutting, drainage crossings by alignment the track on watersheds etc.
3. Maintenance cost should be minimum. Maintenance cost can be reduced by avoiding deep cutting, very high banks, long viaducts, tunnels and heavy gradient which cause heavy wear on rails and rolling stock.
4. It should have easy gradient so that locomotives can haul more load and the transport charges may be minimum
5. It should give maximum safety to passengers without any chance of accidents or derailment.
6. It should pass through important cities and industrial areas
7. It should pass through aesthetic areas so that passengers may enjoy their journey.

Forces acting on the track

A rail is subjected to heavy stresses due to the following types of forces.

1. Vertical loads consisting of dead loads dynamic augment of loads including the effects of speed the hammer blow effect the inertia of reciprocating masses
2. Lateral forces due to the movement of live loads, eccentric vertical loading, shunting of locomotives.
3. Longitudinal forces due to tractive effort and braking forces etc.
4. Contact stress due to wheel and rail contact
5. Stresses due to surface defects such as flat spots on wheels.

Concept of coning of wheels

The art of providing an outward slope of 1:20 to the threads of wheel is known as coning of wheels On straight portions of the track if the axle moves towards one track rail the diameter of the wheel rim over that rail increases whereas it decreases over the opposition.

Advantages of coning of wheel

1. It gives smooth riding
2. It helps a vehicle to negotiate a curve smoothly
3. It reduces the wear and tear of wheel flanges

Tilting of rails

In order to minimise the disadvantage caused by coning of wheels, the rails are tilted inward at an angle of 1in 20. This reduces wear and tear on rails as well as on the tread of wheel
The main object of tilting of rails is to reduce wear and tear on rails as well as on the tread of the wheel .The main object of tilting of rails is to reduce the wear on this edges of rails in track

It is the rate of rise or fall of the track. The railway track has to be provided with a longitudinal slope for connecting two stations which are at different levels.

Classification of gradients

1. Maximum gradient
2. Momentum gradient
3. Pusher gradient
4. Station yard gradient

Maximum gradient :

It is the maximum gradient allowed on the railway track section. It depends on the extra power of the engine. More power is required if the gradient is steeper. In India for plain areas a ruling gradient of 1 in 150 to 1 in 200 and for hilly areas a ruling gradient of 1 in 100 to 1 in 150 is provided.

Momentum gradient :

The rising gradient on which a moving train takes the advantages of the proceedings falling gradient in developing the momentum and kinetic energy for its negotiation is called momentum gradient. For example in valleys a falling gradient acquires sufficient momentum.This momentum gives additional kinetic energy to the moving train which would enable the train to overcome a steeper rising gradient than the ruling gradient for a certain length for a certain.

Pusher gradient:

The gradient which requires one or more additional locomotives for pulling the train up the track is called pusher gradient. These gradients are always steeper than the ruling gradient . These gradients are always steeper than the ruling gradient.
It is not possible to restrict the gradient to the ruling gradient in hilly areas.

Station yard gradient:

Gradient on platform are due to the reason given below:
At the starting moment the engine will require extra force to pull the train along up gradient. Bogies in yards would start moving in the direction of the down gradient if the direction of the wind is also towards the down gradient of 1 in 1000 has been prescribed by the indian railways.

Rails

Rails are rolled steel sections laid along two parallel lines over sleepers. They can be considered as steel girders carrying axle loads. Rails are made of high carbon steel to withstand wear and tear.They should also be strong enough to bear the load and impact which may come from them. Rails should also be constructed in such a way that every portion can be easily maintained.

Function of rails

1. To provide a continuous and level surface and level surface for the movement of trains
2. To provide a smooth pathway to train. This pathway to trains. This pathway has very less friction.
3. to transfer the wheel loads to the sleepers, ballast and the formation between them and the safe limits.
4. To bear the vertical and lateral forces of the trains moving at high speeds
5. To bear the the thermal stresses due to change in temperature as well as braking force caused while stopping the trains at railway stations
6. To have minimum wear to avoid replacement charges and failure of rails due to wear.

Requirements,

1. They should be of proper composition of steel
2. the rail should possess adequate lateral stiffness and vertical stiffness
3. Rails should be capable of withstanding lateral forces.
4. The head must be sufficiently deep to allow for an adequate margin of vertical wear.

5. The thickness of web of rail should be sufficient to take safely the load coming on the rail
6. The width of foot of rail should be sufficient to grant stability against overturning and it should be capable of spreading the load on a large area of the sleeper

Types of rails

Double Headed rails

These rails were provided at the first stage of development. It consists of three parts .ie., lower table, web and upper table.
The upper and lower tables are identical. These were kept the same with the ideas of increasing the life of the rails. The idea was to increase the life of the rail.
The idea was that when the upper table had worn out due to the impact of moving wheels it could be inverted and reused with the lower section at the top.
Later it was found that impact of wheels, the lower table become dented and not be reused for smooth riding

Bull headed rails

These rails consist of head web and foot and are made of steel. the head is larger than the foot. In this rail the metal in the foot is sufficient to bear the stresses caused by moving wheels.
In bull headed rails bottom portion was designed only to properly hold the wooden keys with which the rails are fitted to chairs

Flat footed rail

These rails were invented by charles vignole in 1836 at the same time when BH rail was designed. Therefore these are also known as vignole rails. In this case the bottom section is spread out to form a base.
The idea behind the invention was that this rail can be directly used on sleeper with few fastening These rails are mostly used on indian railways due to its more lateral stability. About 90 percent of railway track in the world is laid with these rails due to the following advantage

1. These do not require any chair. The foot of the rail is spiked directly to the sleeper
2. These are stiffer both vertically and laterally than B.H rails of equal weight
3. These are cheaper than B.H rails
4. These distribute load over greater number of sleepers
5. These tend to increase the life of the sleepers and rail
6. These tend to reduce the maintenance costs.

Methods to reduce wear, creep, causes, effects and prevention

Wear

A rail may face wear and tear
On Top of the rail head

On the sides of the rail head
Wear is more prominent at following location
On sharp curves due to centrifugal forces
On steep gradients due to the extra force applied by the engine.
On approaches to railway stations, possibly due to acceleration and deceleration.
In tunnel and coastal areas due to humidity and weather effects.

Creep:

Creep is the longitudinal movement of rails in a track. Creep is common to all railway tracks but varies in magnitude considerably, the rail in some places, moves by several centimeters in a month while in other locations the movement of rails may be negligible.

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.

Changes in temperature:

Temperature variations cause unequal expansion and contraction of rails. Creep is more in hot weather than cold weather than cold weather.

Brake:

Creep is also caused due to forces that come into operation when it starts the wheel pushing the rails backward and when it stops the wheels push the rails forward.

Track alignment:

Creep is more on curves than come into operation when the train is stopping stops the wheels push the rails forward

Track gradient:

Creep is more on steeper gradient than on straight tracks.

Poor maintenance:

When the tracks are not maintained properly more creep develops. Fish plates and fish bolts become loose.

Sleepers

Sleepers are transverse support for railway track to give stiffness to it. In a permanent way sleepers add to the general stability and form a very important component of the railway track Rails have to withstand

the heavy load from the locomotive, wagons and coaches.In the absence of sleepers the track would just settle down.

Functions of Sleepers

1. To provide stability to the permanent way.
2. To allow track insulation for electrified rails sections
3. To hold the rails to required gauge
4. To support the rails firmly
5. To provide facilities for maintaining the track at proper grade
6. To absorb the vibration of the trains
7. To behave as elastic medium between the rails and ballast
8. To distribute the load from the rails to a large area of the ballast
9. To provide fastening for easy replacement of fastenings

Requirements of sleepers

1. It should provide sufficient bearing area for the rails
2. It should be easy to fix and remove rails from sleepers
3. It should have sufficient strength so that it can bear heavy stresses
4. It should be of such dimension which are unaffected by tamping and packing
5. It should not create handling and transportation problems
6. It should be able to resist weathering agencies
7. It should be easily insulated from the rails if track circuiting is required
8. It should be neither too heavy nor too light
9. It should be strong enough to resist shock and vibrations

Monoblock prestressed

The railway sleepers are a very important component of railway track structure. The sleepers can be manufactured by using timber, concrete, steel or other engineered materials.
Nowadays, prestressed concrete has become the most commonly used type of sleepers. Prestressed concrete sleepers have longer life-cycle and lower maintenance cost than reinforced concrete sleepers. They are expected to withstand high dynamic loads and harsh environments. However, durability and long-term performance of prestressed concrete sleepers are largely dependent on creep and shrinkage responses.

Elastic fastening

An elastic fastening is usually in the form as a clip. Various types of clip have been developed over the years only some of the elastic fastening listed below.

Pandrol clip or elastic rail clip:

This clip is made of a silico-manganese spring steel bar with diameter of 20.6 mm and is heat treated. It can be fixed on wooden, steel cast iron and concrete sleepers with help of a base plate and other ancillary fittings. It is widely used for concrete sleepers on indian railways

IRN 202 clip:

Designed to suit two block RCC sleepers The clip is manufactured by republic forge of hyderabad using a silico manganese spring steel bar diameter of 18mm suitably heat treated.

Ballast

Ballast is a granular material which is placed and packed below and around the railway sleepers. Different types of ballast materials used are broken.Ballast is an important constituent of convectional track structure. Its importance has grown with the increasing axle loads and train speeds.When ballast is tightly rammed under the sleeper for transmitting the loads, it is termed as Packing.It is referred to as boxing when loosely filled on slopes and thrown around the sleepers.

Function of Ballast

1. To distribute the load uniformly over large area of formation
2. To provide elasticity and resilience to track
3. To drain off the rainwater from track
4. To prevent lateral and longitudinal movement of sleepers
5. To hold the sleepers in position when the train passes over them
6. To prevent the growth of weeds inside the track
7. To protect formation from direct exposure to rain frost or sun

Requirements of Ballast

1. It should allow for easy and quick drainage of the track,
2. It should not have any chemical actions on rail and steel sleeper.
3. It should be cheaply and easily available
4. It should be capable of maintaining the depth uniformly throughout so that the loads are distributed uniformly on the formation
5. It should be easy to clean
6. It should have good workability so that it can be easily laid on formation.

Broken stone ballast

Broken stones satisfy all requirements of ballast. Mostly this type of ballast is used on Indian railways. Broken Stones is produced from stones of good quality like hard trap, quartzite and granite. It should be hard though non porous.Graded stones from 50mm to 20mm provide maximum stability to the railway track.Large sized stones are used for flat bottom sleepers such as wooden concrete CI They transfer the load uniformly.Good quality hard stone is normally used for high speed track.

Fixtures and Fastening

These fish plates are used to connect rails and sleepers together to form the track are known as fixtures and fastening

The purpose in order to ensure the smooth running of trains.

Fish plates

These plates are used to maintain the proper alignment of the rail line; they maintain the continuity of rails and also allow expansion or contraction of rails caused due to temperature variation At each joint a pair of fish plates is used. Holes are drilled through the plates and web rails. The rail are joined together by tightening fish bolts with the help of nuts.

Rail joints

Rail joints are necessary to hold together the adjoining ends of the rails in the correction position both in the horizontal and vertical planes.

Types of rail joints

Depending upon the position of joints, the rail joints are classified as follows:

1. Square joints
2. Staggered joints

According to the position of sleepers, the rail joints are of the following three types:

1. Suspended joints
2. supported joints
3. Bridge Joints

Welding of Rail

The rail joints in which both the adjoining ends of rails are welded together by a suitable type of welding are known as welded rail joints.

Short welded rail

The short welded rail is welded rail that contracts and expands throughout its length itd length
These rails are composed of 3,5, or 10 rails weld together.

Long welded rail

The long welded rail is welded rail in which the central portion does not undergo any longitudinal contraction or expansion due to temperature variation.

Continuous welded rail

The continuous welded rail is a type of LWR that continues through stations yards, including points and crossings

Comparison of SWR, LWR, CWR

SWR	LWR	CWR
A welded rail which expand and contact throughout its length.	A welded rail the central the central portion of which does not undergo any thermal expansion	A welded rail like the LWR which has to be distressed in stage
3-5 rail lengths Expansion	0.5- 1 km switch expansion	Above 1 km switch expansion
Normal expansion contraction	Theory of locked u stresses in the rail with no stresses	Same LWR
Not required	Can be done in one stage	Has to be done in stages
Can be maintained any time in anyway.	Regulated maintenance in specified temperature range	Same as LWR
Minimum	More than SWR	Almost the same as LWR
Minimum due to a large number of joints	Better than SWR	Best
Manual	Both manual & Mechanized	Same as LWR