**Railway Engineering**

**Introduction**

**Advantages of railway over highway**

Construction of route:   
In roadways, these routes consist of suitable pavement of specified width provided usually with shoulders on either side.   
In railways, the routes consist of pair of steel rails which are laid parallel to each other on sleepers at fixed distance apart.   
  
Suitability to traffic:   
In roadways, routes are meant for movement of different types, of traffic such as *buses, trucks, scooters, rickshaws, cycles, pedestrians* etc.  
  
The railway routes are meant only for movement of trains.   
  
Width of right-of-way:  
The roadway routes require more width of right-of-way.  
  
The railway routes require less width of right-of-way.   
  
Starting and destinations:   
In roadways, starting and destination points of traffic are not fixed.  
  
In railways, starting and destination points of trains are always fixed.   
  
Right of entry:   
In roadways, the right of entry is free to all vehicles because their movements are not according to any schedule.  
  
In railways, the right of entry is not free to all railway vehicles because their movements are always according to schedule.   
  
Strength of route:   
The required strength of roadways is less.  
  
The required strength of railway tracks is more.   
  
Elasticity:   
The roadway routes do not require an elastic structure since they are not to withstand impacts of heavy wheel loads.   
  
The railway routes require an elastic structure to withstand impact of heavy wheel loads.   
  
Gradients and curves:   
In roadways, the routes can be constructed with steep gradients and sharp curves. Thus, route length in their case is less.  
  
In railways, these routes cannot be constructed with steep gradients and flat curves. Thus, route length in their case is more.   
  
Tractive resistance:   
The tractive resistance of roadway routes is high (5 to 6 times the tractive resistance in case of railway).  
  
The tractive resistance of railway routes is low (1/5th to 1/6th the tractive resistance in case of roadways).   
  
Load handling capacity:   
The load handling capacity of road vehicles is less and that too at low speeds.  
  
Load handling capacity of railway vehicles is more and that too at high speeds.   
  
Requirement of turning devices:   
In roadways, no special turning devices are constructed for turning vehicles on these routes.  
  
In railways, special turning devices in the form of **points and crossings** are constructed for turning vehicles on these routes.   
  
Operational control devices:   
In roadways, no special operational control devices in the form of **signaling** and **interlocking** are required on these routes for safe and efficient movement of vehicles.  
  
In railways, special operational control devices in the form of signaling and interlocking are required on these routes for safe and efficient movements of trains as per schedule.   
  
Suitability to transportation of people and goods:  
Transportation of people and light goods for short distances(upto 500 km) is convenient and cheap by roadway routes.  
  
Transport of people and heavy goods like *raw materials*, coal, ores, etc. for long distance or manufacturing concerns is convenient and cheap by railway routes.   
  
Adaptability to type and size of goods:   
All types and sizes of goods cannot be handled by road vehicles.  
  
Almost all types and sizes of goods can be handled by the trains.   
  
Suitability for hilly area:   
Roadway vehicles are more suitable for hilly area.  
  
Railway vehicles are less suitable for hilly area.   
  
Employment potential:   
Roadways have less employment potential.  
  
Railways have high employment potential.   
  
Rate of accidents:   
In roadways, the rate of accidents is high.  
  
In railways, the rate of accidents is less.   
  
Construction and maintenance cost:   
The construction and maintenance cost of roadway vehicles is less.  
  
In case of railway vehicles, the cost is more.

**Basic definitions of railways:**

1.Stability to transportation of people and goods .

**Classification of Indian railways:**

Based on gauge:

1.Trunk routes: consists of six routes of broad gauge and three routes of meter gauge.

On broad gauge : 1.Delhi-Mughalsara-Howrah

2.Delhi-kota-mumbai

3.Delhi –Jhansi-Nagpur-Chennai

4.Howrah-Nagpur-Mumbai

5.Mumbai-Guntakal-Chennai

6.Howrah-Vijayawada-Chennai

On meter gauge:1. Lucknow-Gorakhpur-Guwahati

2. Delhi-Jaipur-Ahmedabad

3.Chennai-Madurai-Trivendrum

2.Main lines: All lines other than trunk routes carrying 10 gross million tonnes/annum(GMT) or more for B.G. and 2.5 GMT or more for M.G. or where min. permissible speed allowed is 100 kmph for B.G. and 75 kmph for M.G. are classified as main lines .

3. Branch lines : B.G. lines which carry less than 10 GMT / annum and max. permissible speed of <100kmph are classified as branch lnes.

For M.G. tracks all those lines which carry <2.5 GMT / annum and have max permissible speed < 75kmph

a)B.G. locomotive and wagons allowed to operate overall branch lines at reasonable speed.

b)M.G. engines and wagons with max. axle load of 12 tonnes would be permitted .

Based on speed :

1.Group A line: It consists of trunk routes on which train are running or meant for run 160kmph or more ; B.G. first four routes are comes under this category

2. Group B Lines: Max speed on this road is 130 kmph are running or intended to run at a present 13 routes comes under this category.

3. Group C Lines: consists of sub urban routes ofmumbai, Calcutta and delhi

4. Group D lines : routes in country where max permissible speed at present is 100kmph

5. Group E lnes: other routes and branch lines where max permissible speed limits are< 100kmph

**Permanent way:**

\*Combination of rails fitted on sleepers and resting on ballast and subgrade is known as permanent way on Railway track.

\* sometimes temporary tracks are also laid for conveyance of earth and materials during construcon work .

\* In permanent way rails are joined in series by fish plates and bolts then they are fixed to sleepers by different types of fastenings.

\*Sleepers properly spaced ,resting on ballast ,are suitably packed and boxed with ballast .

\* The layer of the ballast rests on the prepared subgrade called the “ Formation “.

\* The rails act as girders to transmit the wheel load to the sleepers .Sleepers holds the rails in proper position with respect to the proper tilt gauge and level and transmit the load from rails to the ballast.

\* The ballast distributes the load over the formation and hold the sleepers in position.

\*On curved tracks, super elevation is maintained by ballast and the formation is levelled .

Minimum ballast cushion is maintained at the inner rail , while outer rails gets more ballast cushion.

Additional quantity of ballast is provided on the outer of each track for which base width of the ballast is kept more than for a straight track .

**Requirements of permanent way:**

Permanent track is regarded to be semi elastic in nature.

There is a possibility of track getting disturbed by the moving wheel loads.

It should be constructed and maintained keeping the requirements of a permanent way,in view ,so as to achieve higher speed and better riding qualities with less future maintenance.

a)Gauge should be comfort and uniform.

b)Rails should be in proper level.

In straight track rail must be at the same level.

On curved,the outer rail should have super elevation and there should be proper transition at the junction of a straight and a curve.

c)Alignment should be correct i.e,should be free from kinks and irregularities.

d)Gradient should be uniform and as gentle as possible.

Any change of gradient should be followed by a smooth vertical curve, to give smooth riding quality.

e)Track should be resilient and elastic in order to absorb shocks and vibrations of running track.

f)Track should have enough lateral strength .So that alignment is maintained even due to effects of…

1)Side thrust on tangent length and centrifugal force on curves

2)Lateral force due to expansion of rails particularly in case of welded rails.

g)Radii and super elevation on curves should be properly designed and maintained.

h)Drainage system must be perfect for enhancing safety and durability of track.

k)Joints, including points and crossings which are regarded to be weakest points of the railway track,should be properly designed and maintained.

l)If there is trouble from the creep,preventionary measures should be taken prevent it.

m)Various components f track i.e,rails, fittings, sleepers, ballast and formation must fully satisfy the requirements for which they have t be provided.

If any component is lacking in fulfilling its requirements then it should be improved or replaced.

n)There should be adequate provision for easy renewals and replacement .

o)Track structure should be strong ,law in initial cost as well as maintainence.

**Gauge:**

Clear distance between inner or running faces of two track rails.

Distance between inner faces of a pair of wheels is called WHEEL GAUGE.

**Different gauges in in India :**

Standard gauge:

Whose gauge length is 1435mm and these are available through out the world on average 62% of the countries.

Broad gauge:

Clear distance of 1676mm or 1524mm.

On an average throughout the world 15% countries are using.

Ex:India,Pakistan,Srilanka,Brazil developing countries.

Cap gauge:

1067mm;8%of the total guage.Ex:Africa,Japan,Australia.

Meter gauge;

1000mm; 9% of the total gauges.Ex: India, France ,Switzerland.

Other than this 23 gauges are there diffirent countries of world .

In India :

\*In India 63% route km are 676 mm but like some of countries 1524 mm is not adopted in india B.G.

\*In an other case of M.G. 31% of rote km is provided through out the India .

\*There is another gauge narrow gauge which is provided I specific areas in our country and clear dim is 762mm or 610mm and it consists 6% of route km.

These are found mostly in hilly areas where terrains are such that we can’t go for bigger gauges .

**Selection of gauge :**

1.cost of costruction : there is a little increase in initial cost if wego through B.G.

A)Cost of bridges,tunnels,station buildings,staff quarters ,signals,cabins and level crossings same for all the gauges.

B) Cost of earth work( cutting and filling) ballast , sleepers,rails etc, increase with increasing gauge width .

C) And increase in acquisition of land for permanent track with increase in gauge

D)Cost of rollings stock is independent of gauge used for the same volume of traffic.

2.Volume and nature of traffic : Greater traffic volume and greater load carrying capacity train should be run by better locomotives and for heavier loads and high speed the wider gauges are required because subsequently the operating cost per tonne-km is less for higher carrying capacity .

3.Development of the areas : N.G. can be used to develop thinly populated areas by joining the under developed or unurbanised areas.

4. physical features of country : In hilly areas we should go through N.G. because of less space and in plains also, where high speed is not required and traffic is light N.G. is right choice .

5. Speed of moment: Speed of moment of train is directly proportional to gauge.

\* speed is for dia of wheel, which turn is limited by gauge . wheel dia is 0.75 times that of gauge for hgh speed B.G. is used .

Uniformity of gauges:

Gauge should be uniform through out as far as possible in country.

Uses of uniformity is …….

1.Delay , cost , and hardship in transhipping passengers and goods from the vehicles of one gauge to another is avoided .

2. Transhipping is not required , there is no breakage of goods .

3.Difficulties n loading and un loading are avoided and labour expenses are saved.

4. Possibility of thefts and misplacement, while changing from one vehicle to another is eliminated.

5.Large sheds to store goods are not required .

6. Labour strikes etc., do not effect the service and operation of trains .

7. Surplus wagons of one gauge cannot be used on another gauge.This problem will not arise if gauge is uniform .

8. Locomotives can be effectively used on all the tracks if a uniform type of gauge is adopted.

9.Duplication of equipment such as platforms,sanitary arrangements,clocks etc.,avoided.This saves a lot of extra expenditure.

10.During military movements,no time is wasted in changing equipment from one vehicle to another if gauge is uniform.

11.It is expensive to convert one gauge into another at later stages it may require new rolling stock,fresh construction and widening of bridges and tunnels.

12.Due to late arrival of trains at junction where change of gauge is involved missing links result in number of difficulties.Passengers has to pass time on platforms.

13.Porter charges are increased when passenger have to change compartments due to different gauge.

**Conning of wheel**

Distance between inside edges of wheel flanges is generally kept less than the gauge of the track minimum 10m gap is provided.And the thread of wheel is dad end of the rail head.

ADVANTAGES:

1.Reduce wear and tear of the wheel flanges and rails which is due action of flanges with inside face of rail head.

2.Provide a possibility of lateral movement of axle with its wheels.

3.Prevent the wheels from slipping to some extent.

Theory of coning:

**Rails**

**Functions of rails**

* Minimum Friction
* Stress due to heavy vertical loads, lateral and braking forces and thermal stresses
* Minimum wear to avoid replacement charges and failures
* Transmit loads to sleepers

**Requirements of rails**

* Proper composition
* Vertical stiffness
* Withstand lateral forces
* Web of rail should have sufficient thickness
* Wearing surface
* Food should be wide enough against overturning
* Tensile strength of rail >72kg per m^2

**Types of rails**

Bull headed

Double headed

Flat footed

**Corrugated rails or roaring rails:** Head of rails are found to be corrugated rather than smooth & straight when vehicle moves on it roaring sound is created.

**Hogged rails:** Due to battering action of wheels at enf the rails get bend down.

**Remedial measures** :

* Cropping
* Replacing
* Welding
* Dehogging

**Kinks in rails:** End of adjoining rails are move out slightly out of its position kinks or shoulders are formed.

**Buckling of rails:** Track gone out of its position due to expansion of rails in hot weather.

**Damaged rails:**

* Wear of rails
* Defect due to manifacture of rails
* Defect of hogging in excess
* Damage cause to rails

1. Careless unloading & handling
2. Bending rails at curves
3. Skipping and skidding of wheels due to overloading
4. Due to damaged tires
5. Braking to due to accidents

**Wear on rails:**concentrated stresses exceed the elastic limit resulting in metal flow

* Based on position

1. Wear on head of rail
2. Wear on ends of rails
3. Wear on sides

**Based on location:**

* On sharp curves
* On gradients
* Where breaks frequently applied
* Coastal areas
* In tunnels

**Methods to reduce wear:**

* Use special alloys
* Regular tightening of fish bolts
* Reduce no of joints
* Maintenance of track
* Changing inner and outer rails.
* Welding or battered end time will also reduce

**Rail failures:**

* Crushed head
* Square or angular break
* Split heads
* Spilt web
* Horizontal fissures
* Transverse fissures
* Flowing metal in heads

**Sleeper**

**Functions of sleepers**

* Hold rails correct gauge
* Hold the rails in proper level
* Act as elastic medium in B/w ballast and rails
* Distribute the loads from rails to ballast
* Sleepers add longitudinal and lateral stability of track
* Support rails proper super elevation on curves

**Requirements of sleepers**

* Economical
* Easily adjustable
* Weight should not too heavy or light
* Design of sleepers should be that gauge, alignment & level of rails easily adjusted
* Enough to resist crushing due to rail seat & crushing of ballast
* Capable of resist shocks & vibrations
* Not damaged due to packing process

**Classification of sleepers**

* **Timber**
* **Metal sleepers**
* **Reinforcered concrete**

**Timber**

* Best as they fulfill almost all required
* Life depends on ability to resist wear, decay, attack by vermin, quality of timber



**Types of timber for sleepers**

* Hard wood Ex: sal, teak
* Soft wood Ex: chir, deodar
* Strength & weight of chir & deodar are 2/3rd of teak
* Deodar fairly hard & can stand extremes dampness & dryness

**Treatments**

* Treated sleepers > 30 to 50% of untreated
* Timber has millions of minute cells. These cells contain juices, removal of juices & filling up the cells with preserving solution Ex: bichloride of mercury

**3 methods of impregnating**

* Full cell process
* Empty cell process
* Haskenizing process

**Advantages**

* Easily available
* Simple in design
* Easy to lay & relay, pack, lift & maintenance
* Economical
* Able to resist shocks and vibrations

**Disadvantages**

* Subjected to wear, decay, attack by white ants, cracking & splitting
* Difficult to maintain gauge
* Easily disturbed
* These have min service life 12 to 15 yrs compared to other
* Maintenance is high

**Metal sleepers**

**Requirements**

* Should bear tensile and compressive stress which comes on them
* Should provide sufficient area for rails
* Tamping and packing of ballast shouldn’t disturb sleeper
* For track circuiting should be possible
* Economical compared to wooden sleepers
* Provide ease in fixation & removal of rails
* Provide sufficient grip on the rails & ballast to prevent dislocation of track

**Advantages**

* Uniform strength & durability
* Economical & life is larger & maintenance is easier
* Gauges can be easily adjusted
* Frequent renewal not required
* Have good scarp value, easy in manufacturing & not susceptible to fire hazards
* Has lesser creep occurs

**Disadvantages**

* More ballast requires
* Fitting required are more in num & difficult to maintain & inspection
* Liable to rusting
* Good conductor of electricity
* Unsuitable for bridges, points & crossings

**2 Types of sleepers**

* **Cast Iron**
* **Steel sleepers**

**Cast Iron**

* **Pot or bowl sleepers** : 2 bowls placed inverted on the ballast and connected by steel strip. On top of pot rail seat is provides to hold F.F. or B.H. rail.

Effective bearing area for rail support is 0.232 sq.m. can’t be used on curves.

* **Box sleepers :**
* **Plate sleepers :** rectangular whose sides are parallel to the rails projecting ribs under plate for lateral stability

Plates held in position with tie bars

Effective bearing area 0.464 sq.m. for F.F. or B.H.

* **Rails free duplex :** it has been use in joints. These are used to prevent cantilever action b/w 2 sleepers at joints.
* **Combination of plate & box(C.S.T. 9)** : extensively used in Indian railways past 30yrs because of satisfactory results

It has triangular inverted pots on either sides of rail seat, plate with projecting rib & box on top of that.

It can be easily assembled & dismantled easily

Bearing area almost equal to wooden sleeper

**Steel sleepers**

* **Key type:** keys are used to hold rails In pressed up lugs or in loose jaws fitted in holes of the sleepers.
* **Lugs or Jaws pressed out of metal :** formed by pressing out the metal of channel section.
* **With loose lugs or jaws :** holes are drilled or punched in the plate to accommodate loose jaws.
* **Clip and bolt :** clips & bolts are used to hold rails. holes for bolts are small & circular. There may be a chances of cracking due to these holes. But these sleepers prevent creep in rails & gauge also maintained properly.

**Saddle type :** rail seat is strengthen by a saddle plate. Which has 2 holes corresponding to holes in sleeper on either sides of rails

**Concrete sleepers**

* **Advantage**
* **disadvantage**

**R.c.c. sleepers :**

**1)Through type :** This is also known as one piece or mono-block sleeper. In this type of sleepers cracks develop on the tension side when stressed. These cracks are very small ad almost invisible but tend to enlarge with the repetition of impact loading, causing failure.

**2)Composite or Block & Tie Type:** This type of sleeper consist 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.

**P.c.s. :** min cube crushing strength of concrete 422kg/cm^2 at 28days & wires are stressed to initial stress of 8.82 kg/cm^2

**Spacing of sleepers**

* spacing depends on axel load, type of ballast & ballast cushion, type & strength of sleepers, natural foundation, type & section of rails
* In India for manual packing of ballast min distance 30.5 to 35.5cm at joints
* Now a days in India tie tampers are used so distance reduced to 25cm
* Sleeper density is no of sleepers per rail length. In India it varies from n+4 to n+7 (n is length of rail in yards)

i.e. no of sleeper = M+4 or M+7 (M is length of rail in meter)

* joints On curves we use to provide 1 extra sleeper

**Ballast**

**Functions of ballast**

* Transfers loads from sleepers to large width of formation
* Holds sleepers in position
* Imparts some degree of elasticity
* Easy to correct level in straight line as well as super elevation
* Provides good drainage

**Requirements f ballast**

* Should resist crushing under dynamic loads
* Should provide good drainage with min soakage
* It should not make track muddy due to powder under dynamic loads
* Should resist to abrasion & weathering
* Shouldn’t produce any chemical action with
* Sizes 5cm for wooden, 4cm for metal, 2.5cm for turnouts
* Materials should be easily workable
* Should be available nearly

**Types of ballast**

**Renewal of ballast**

* Due to prolong movement of wheel load ballast material get crushed to smaller size
* Quantity of ballast also reduced

1. Blowing away
2. Penetration
3. Due to rain water

* So time to time renewal required crushed fine material is removed by screening & new material of desired size is added