MODULE – 1

RAILWAY ENGINEERING

A French mechanic, named Nicholas Joseph Cugnot, was the first man to invent and construct a steam locomotive in the year 1769. The first public railway in the history of world was opened for traffic on 27th September 1825 in England.

Characteristics of railways:

(i) The railways are the biggest undertaking in the world. They employ many people and carry out considerable turnover.

(ii) The railways exist practically in all the parts of the world.

(iii) The railways are the cheapest in preference to other modes of transport.

(iv) The railways require the least amount of power as compared to their weight.

(v) The direction of movement is controlled and the vehicles are not at liberty to deviate from the rails.

(vi) The railways alone can carry lots of people quickly and safely through big towns full of crowded streets.

(vii) As compared to other modes, it is better to travel in a train for making long journeys, carrying a lot of heavy things.

COMPARISON BETWEEN RAILWAYS AND HIGHWAYS

Characteristics	Railways	Highways
1. Tractive Resistance	Tractive resistance of a steel wheel on a steel rail is less, nearly one fifth to one sixth of pneumatic tyre on highways	Tractive resistance of pneumatic tyre on highways is 5 to 6 times greater than that of railway vehicles on steel rails
2. Load handling capacity	Railway can handle heavier loads at high speeds	Load handling capacity of road vehicles is low
3. Right of entry	Movement of vehicles is according to schedule and hence right of entry is not free to all	Roads are free and flexible and everybody has right to ingress or egress
4. Operational controls	Essential in the form of signalling and interlocking for safe and efficient movement of trails as per schedule	No rigid controls are required in road transport
5. Gradient	To sustain heavier loads at high speeds on railways, the gradient should be minimum	Steeper gradients as compared to railway track can be provided
6. Construction and maintenance cost	The establishment and maintenance cost of railways is much higher than roads	Its cost of construction and maintenance is comparatively less
7. Origin and destination	In railways starting and destination points are fixed	Not fixed. This mode provides door to door service
8. Time consumption	For long distances it is cheaper and convenient though little more time consuming	This is best suited for short distances

9. Adaptability to size and type of load	Railways can handle almost all types and sizes of goods	Adaptability of highways to size and type of load is restricted by size of vehicle
10. Right of way	Width of right of way is lesser for railways	Highways require greater width for right of way
11. Use	Reserved only for the movement of trains	Used by different types of vehicles such as cars, trucks, two wheelers, buses etc.
12. Horse Power	Lesser HP per tonne	Higher HP per tonne

ADVANTAGES OF RAILWAYS

Political Advantages

i. Railways have united the people of different castes, religions, customs and traditions.
ii. With the adequate network of railways, the central administration has become more easy and effective.
iii. Railways have contributed towards development of a national mentality in the minds of the people.
iv. The role of railways during emergencies in mobilizing troops and war equipment has been very significant.
v. Railways have helped in the mass migration of the population.

a) ***Social Advantages***

i. The feeling of isolation has been removed from the inhabitants of the Indian villages.
ii. By traveling together into the compartment without any restriction of caste, the feeling of caste difference has disappeared considerably.
iii. The social outlook of masses has been broadened through railway journeys.
iv. Railway has made it easier to reach places of religious importance.
v. Railways provide a convenient and safe mode of transport for the country.

b) ***Economic Advantages***

i. Mobility of people has increased, thereby the congested areas can be relieved of congestion and the sparsely populated areas can be developed.
ii. Mobility of labour has contributed to industrial development.

iii. During famines, railways have played a vital role in transporting food and clothing to affected areas.
iv. Growth of industries has been promoted due to transportation of raw materials through railways.
v. Speedy distribution of finished products is achieved through railways.
vi. Railways provide employment to millions of people and thus help in solving the unemployment problems of the country.

c) Techno-Economic Advantages

i. Cost saving in transportation of long haul bulk traffic.
ii. Energy efficiency.
iii. Environment friendliness.
iv. Higher safety.
v. Efficient land use and ease in capacity expansion.

INDIAN RAILWAYS

Indian Railways is operated by the Ministry of Railways. It manages the fourth-largest railway network in the world by size, with 121,407 kilometers of total track over a 67,368-kilometre route. There are four gauges in India: Metre gauge, Narrow gauge, Broad gauge and Standard gauge. Currently, unigauge project is in progress to convert all tracks to broad gauge.

Indian Railways is divided into several zones, which are further sub-divided into divisions. The number of zones in Indian Railways increased from six to eight in 1951, nine in 1952 and sixteen in 2003. Each zonal railway is made up of a certain number of divisions, each having a divisional headquarters. There are a total of sixty-eight divisions. Each of the sixteen zones is headed by a general manager who reports directly to the Railway Board. The zones are further divided into divisions under the control of divisional railway managers (DRM).

History of Indian Railway

On 1st of August, 1849 the Great Indian Peninsular Railways Company was established in India. On 17th of August 1849, a contract was signed between the Great Indian Peninsular Railways Company and East India Company. As a result of the contract an experiment was made by laying a railway track between Bombay and Thane (56 Kms).

- On 16th April, 1853, the first train service was started from Bombay to Thane.
- On 15th August, 1854, the 2nd train service commenced between Howrah and Hubli.
- On the 1st July, 1856, the 3rd train service in India and first in South India commenced between Vyasarpadi and Walajah Road and on the same day the section between Vyasarpadi and Royapuram by Madras Railway Company was also opened.

Subsequently construction of this efficient transport system began simultaneously in different parts of the Country. By the end of 19th Century 24752 Kms. of rail track was laid for traffic. At this juncture the power, capital, revenue rested with the British. Revenue started flowing through passenger as well as through goods traffic.

DEVELOPMENT OF THE INDIAN RAILWAY

The development of Indian railways can be broadly split up into five stages:

1. The old guarantee system
2. State construction and ownership
3. The modified guarantee system
4. Nationalization
5. Integration and regrouping

1. **The old guarantee system (1849-1869):** Eight companies entered into contract with East India Company for running the railways. Shareholders were relieved of all risk and they were given expectation to receive certain profit over and above the guaranteed interest. The ultimate right of purchase and full powers of supervision vested with the government.
2. **State construction and ownership (1869-1882):** Government purchased existing railways and constructed new lines, since the administration of railway companies was not upto the standard.

3. **The modified guarantee system (1882-1924):** Various small princely states of India, existing at that time, contributed to the extent of about 12165 km to 41279 km of railway lines owned by the government of India at that time.
4. **Nationalization (1924-1944):** The whole railway lines were nationalized during the period 1924-1944, based on recommendation Acworth Committee.
5. **Integration and regrouping (1944-1966):** After independence, with integration of different princely states, the Indian Government Railways, the largest public sector undertaking of the country was formed. Again the whole railway was divided into a number of zones.

ROLE OF INDIAN RAILWAYS IN NATIONAL DEVELOPMENT

Indian Railways has successfully played the role of the prime carrier of goods and passengers in Indian subcontinent. It is a principal constituent of nation's transport infrastructure. Main roles being

- Helps to integrate fragmented markets and thereby stimulates the emergence of a modern market economy.
- It connects industrial production centres with markets as well as sources of raw materials thereby favouring industrial development.
- Promotes rapid agricultural growth.
- Provides rapid, reliable and cost effective bulk transport to energy sector.
- Links people with places, enabling large scale, rapid and low cost movement of people across the length and breadth of the country.
- It is a symbol of national integration and a strategic instrument for enhancing our defence preparedness.
- Indian railways have a workforce of over 13.6 lakhs, thus being one of the largest employment providers in India.
- Social costs in terms of environment damage or degradation are significantly low.
- Rail construction costs approximately six times lower than road for comparable levels of traffic.

- Railways contribute to a major part in country's GDP through employment generation, freight collection, e-catering services etc
- Railways are an agent of urbanization
- Helps in transportation of raw materials and finished goods
- Railways supports its employees in the education of children, medical treatment, housing etc
- Encouraged tourism by providing special tourist coaches, special trains (eg: Palace-on-Wheels).

CLASSIFICATION OF INDIAN RAILWAYS

Railway board has classified Indian Railway lines on the basis of importance of route, traffic carried and maximum permissible speed on the routes, into the following 3 main categories:

1) **Trunk routes**
2) **Main lines**
3) **Branch lines**

1) **Trunk routes:** Six routes on BG and 3 routes on MG are classified as trunk routes by Railway Board.

   Specifications are:

No	Items	BG	MG
1.	Ballast Cushion	25 cm below sleeper	25 cm below sleeper
2.	Degree of curvature	7.5^{o}	Suitable degree
3.	Design speed for new track	160 kmph	100 kmph
4.	Maximum permissible speed	120 kmph	80 kmph
5.	Rail section	52 kg/m	37.2 kg/m

2) **Main lines:** All lines other than trunk routes carrying 10 Gross Million Tonne (G.M.T.) per annum or more for B.G. and 2.5 G.M.T. or more for M.G. and whose maximum

permissible speed allowed is 100 kmph for BG and 75 kmph for MG are classified as main lines Railway Board. The specifications are:

No	Items	BG	MG
1.	Design speed for new track	120 kmph	75 kmph
2.	GMT per annum	≥ 10	≥ 2.5
3.	Maximum permissible speed	100 kmph	75 kmph
4.	Rail section	52 kg/m	37.2 kg/m
5.	Track laying period	20 years	30 years

3) **Branch Lines:** All lines other than trunk routes carrying less than 10 G.M.T. per annum for B.G. and less than 2.5 G.M.T. or more for M.G. and whose maximum permissible speed allowed is less than 100 kmph for BG and less than 75 kmph for MG are classified as main lines Railway Board.

CLASSIFICATION BASED ON SPEED CRITERIA

Based on speed criteria, BG lines are divided into following 5 groups:

1) **Group 'A' Lines**
2) **Group 'B' Lines**
3) **Group 'C' Lines**
4) **Group 'D' Lines**
5) **Group 'E' Lines**

1) **Group 'A' Lines:** Trunk routes where trains are running or are meant for running at a speed of 160 kmph or more.
2) **Group 'B' Lines:** These are routes on which maximum running speed is 130 kmph.
3) **Group 'C' Lines:** They consist of all suburban routes of Mumbai, Calcutta and Delhi.
4) **Group 'D' Lines:** All other routes in country where maximum permissible speed at present is 100 kmph

5) **Group 'E' Lines:** The other routes and branch lines where permissible speed limits are less than 100 kmph

STRENGTH OF INDIAN RAILWAY

- Large volume of goods and passenger traffic is handled for long distances.
- Steel wheels on steel rails cause low tractive resistance.
- In terms of land use, more efficient than roadways.
- Energy efficient mode of transport, causing less pollution.
- In densely populated regions, rapid transit systems and suburban trains are used.
- Well established organization with skilled and trained personnel.
- Good backing to central government in terms of finance.
- It is a self reliant system with respect to major equipments.

WEAKNESS OF INDIAN RAILWAY

- Large portion of infrastructure is overaged.
- Resource constraint in all respect.
- Technology lags in certain infrastructure.

RECENT DEVELOPMENTS IN INDIAN RAILWAYS

Over various times, Indian Railways had introduced advanced types of train facilities.

- Modernization of conventional railway track through various measures such as upgrading standards of track components, achieving uniformity in gauge etc.
- Switching over to electric and diesel traction from steam traction.
- Automation in signaling and train control systems including track circuiting all major routes.
- Adoption of latest technologies in track evaluation, maintenance and modernization.
- Switching over gradually to computerization for all customer services such as booking, ticketing, reservation, cancellation etc.
- Promotion of passenger facilities and amenities on stations and in trains.

- Promotion of container services.
- Introduction of various fast and superfast trains on all important routes and introduction of deluxe/luxurious trains for attracting tourism.

RAILWAYS FOR URBAN TRANSPORTATION- MODERN DEVELOPMENTS

LRT& MRTS

LRT – Light Rail Transit

LRT is a mode of urban transportation utilizing predominantly reserved but not necessarily grade separated right of way. Electrically propelled rail vehicles operate singly or in trains. Light rail transit (LRT) is a medium capacity mode of mass rapid transport which straddles between the heavy capacity Metro rail and the low capacity bus services. It is a form of rail transit that utilizes equipment and infrastructure that is typically less massive than that used for heavy rail modes i.e. metro rail or subway. In the case of LRT, the trains run along their own right-of-way and are often separated from road traffic. Stops are generally less frequent, and the vehicles are boarded from a platform. LRT may be at grade or grade separated

Advantages

- environment-friendly
- .quality of life and travel improved.
- moderate maintenance costs.
- exclusive right of way and fixed route.
- no air pollution and less noise in neighbourhood.
- avoids traffic congestion through segregation.
- easily blended with urban and natural environment.

Disadvantages

- high construction cost
- creates aesthetic concerns in certain locations
- problems of parking for large number of LRT riders
- have lower operational flexibility

MRTS- Mass Rapid Transit System (underground, subway, elevated railway, metro or metropolitan railway)

It is a passenger transport system in an urban area with a high capacity and frequency, and grade separation from other traffic. Unlike buses or trams, rapid transit systems are electric railways that operate on an exclusive right-of-way, which cannot be accessed by pedestrians or other vehicles of any sort, and which is often grade separated in tunnels or on elevated railways.

Modern services on rapid transit systems are provided on designated lines between stations typically using electric multiple units on rail tracks, although some systems use guided rubber tires, magnetic levitation, or monorail. The stations typically have high platforms, without steps inside the trains, requiring custom-made trains in order to minimize gaps between train and platform.

Usually they run in tunnels in the city centre and sometimes on elevated structures in the outer parts of the city. They can accelerate and decelerate faster than heavier, long-distance trains.

TUBE RAILWAYS

Tube railways are deeper than underground railway, usual depth being 27.45m. The section of a tube railway is completely circular and stations are of the cylindrical form. The section of the tunnel in which the railway lines are laid is circular, therefore these are known as tube railways.

Main aim is to avoid the interference due to pipe lines of gas, seepage, water etc. These railways are generally laid even below the sea or river beds.

Following are the main characteristics of tube railways:

- The railway stations of tube railways are of cylindrical shape.
- Only electric locomotives are used to avoid the smoke and the ventilation problems.

- To get an entrance to the tube railway, normally lifts are used. But now escalators are used.
- Automatic signaling is provided for efficient working.
- Automatic ticket issuing machines are to be installed to save time.
- For tube railway, safety devices are provided. The mechanism is such that the train cannot start until all the doors are closed.

HIGH SPEED TRACKS

High speed tracks are the tracks which allow operation of trains at speeds more than 120 kilometers per hour. These are the requirements of today, due to:

- there is a rapidly increasing demand of transportation
- running of heavy loads at faster speeds safely and economically between the two major terminal stations
- better productivity
- provide better services to customer

The high speed trains can be classified in two categories:

- **high speed tracks:** where the speeds are over 120 kilometers per hour and are up to 250 kilometers per hour
- **super high speed tracks:** where the speeds are above 250 kilometers per hour

The development of high speed tracks requires:

- modified traction like diesel and electric traction instead of steam traction
- Modernization of present track to higher standards.

The development of super high speed tracks requires:

- advanced traction efforts
- track modernization.

The development of high speed tracks consists of:

- modernization of track
- use of better designed rolling stock
- adopting superior type of traction
- better telecommunication and signaling arrangements
- modern techniques of maintenances

For attaining high speeds, electric traction plays an important role. The advantages of electric traction are:

- Exerts great tractive effort since torque is uniform.
- Repairs and renewals are very few.
- Donot use energy while standing.
- Ready for service at any time.
- Handles heavy volume at higher speeds.
- Trains can be accelerated quickly.
- No smoke, hence suitable for underground operations.
- Potential danger of fire is not there.
- With electric traction, there is no wear of rails and rolling stock.

Modernization of track includes maintaining structural strength requirements and geometric requirements.

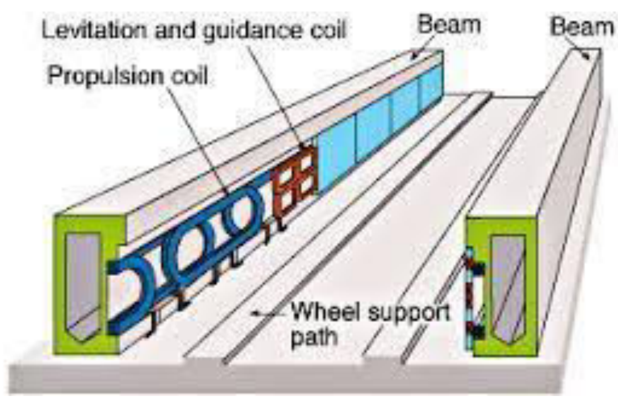
Structural strength requirements include measures like using heavier rail sections which are wear resistant. All measures to improve strength, durability and stiffness of rail sections should be followed. Geometric requirements include using BG track, flat curves, gentle gradients etc.

MAGLEV (Magnetic Levitation)

Maglev (Magnetic Levitation) is one of the costliest system, which uses the magnetic forces for levitation, guidance and propulsion.

There are two technologies for magnetic levitation

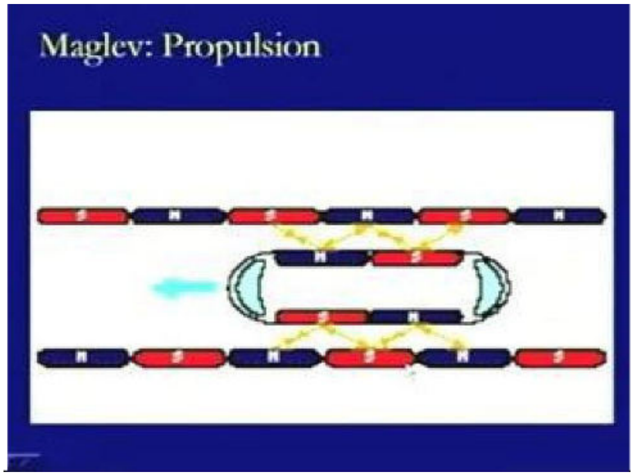
- Electromagnetic Suspension (EMS)
- Electrodynamic Suspension (EDS)



It has wheel support paths and coils are provided on the two sides. The beams on either side encompass the coils. These are known as the propulsion coils as well as there is levitation and a guidance coil. Propulsion, levitation & guidance coils are used for the movement of the vehicle over these support paths and as soon as vehicle takes a higher speed, it will get lifted from the base, about 10 cm and it will be moving into the air. This creates some gap between this and the base of the vehicle. The train does not levitate until it reaches 80 kilometer per hour.

Lateral guidance is achieved with the help of super conducting magnets on train and levitation coils on sides. When the side of the train nears the side of the guide way, the super conducing magnet on the train induces a repulsive force from the levitation coils on the side closer to the train and an attractive force from the coils on the farther side. This keeps the train in the center of the guideway.

For propulsion, an alternating current is ran through electromagnet coils on the guide walls of the guide way and this creates a magnetic field that attracts and repels the superconducting magnets on the train and propels the train forward. Braking is accomplished by sending an alternating current in the reverse direction.



TRACK ALIGNMENT

The direction and position given to the centerline of the railway track on the ground is called the track alignment.

The horizontal profile includes straight path, circular curves & transition curves.

The vertical profile includes gradients and vertical curves.

NECESSITY FOR GEOMETRIC DESIGN

The need for proper geometric design of a track arises because of the following considerations:
(a) To ensure the smooth and safe running of trains

(b) To achieve maximum speeds

(c) To carry heavy axle loads

(d) To avoid accidents and derailments due to a defective permanent way

(e) To ensure that the track requires least maintenance

(f) For good aesthetics

BASIC REQUIREMENTS OF GOOD ALIGNMENT

An ideal alignment should fulfill the following requirements:

1) **Purpose of track:** The alignment of track should be done keeping in view the basic purpose or purposes it is going to serve. In general, the railways serve the following purposes:
    a. Transportation services: carry passenger and goods traffic
    b. Political and strategic: connecting points for defence purposes
    c. Linking of centres: linking of two trade centres
    d. To open up new tracks
    e. Shortening existing track
2) **Feasibility:** For aligning a railway line, it is necessary to carryout feasibility study so that the proposed track alignment melts all technical requirements and also fits in well with general planning of the country.
3) **Economy:** The track alignment should be economical when following factors are given due consideration:
    a. Selecting shortest possible route
    b. Minimizing initial construction cost by avoiding loose earth slopes, rock-cuttings, drainage crossings etc.
    c. Minimizing maintenance cost by avoiding deep cutting, very high banks, long viaducts, tunnels and heavy gradients which cause heavy wear on rails and rolling stock.
    d. Minimizing operation expenses or transportation cost by providing easy gradients, avoiding unnecessary rises and adopting shortest direct route.
4) **Safety:** The track should be so aligned that it gives safety to traffic operations. To achieve this, curves and gradients should be properly designed, and stability of natural slopes, embankments and cut-slopes should be considered. Foundations of embankments should be properly maintained.
5) **Aesthetic aspects:** The aesthetic aspect should be kept in view for comfortable and pleasant journey. This can be achieved by avoiding the view of borrow pits, use of transition curves etc or by keeping the track through beautiful natural surroundings.

FACTORS AFFECTING SELECTION OF GOOD ALIGNMENT

Following factors are considered in the selection of good alignment:

1) Obligatory or control points
2) Traffic
3) Gauge selection
4) Geometric standards
5) Topography
6) Economy
7) Other considerations

1) Obligatory or control points:

It can be classified into two categories:

a) Points through which a track must pass
b) Points through which a track should not pass

a) Points through which a track must pass

a. Important towns and cities: It is desirable that track alignment passes through places of social, commercial, political and defence importance. In fig, if A and B are two main cities and between A and B, there are towns C, D and E. If alignment passes through any of these intermediate towns, there will be a slight increase in the length of track, i.e, length increases from AB_1B to AEC or ACB or ADC. Based on cost-benefit analysis, alignment can be selected.

b. Major bridges or river crossings: the construction of major bridges over large rivers is a costly affair. The route ACB should be selected if bridge B exists and B_1 does not exist.

c. Hill passes or saddles: To avoid unnecessary requirements of deep cuttings or high banks or tunnels or viaducts, the existing passes or saddles should be connected, whenever crossing the hills.

d. Site for tunnels: Though passing of a track through tunnel should be avoided as far as possible but in case off high and thin ridges when a tunnel can be an economical option by avoiding deep cuttings, the track can be aligned through such tunnel sites.

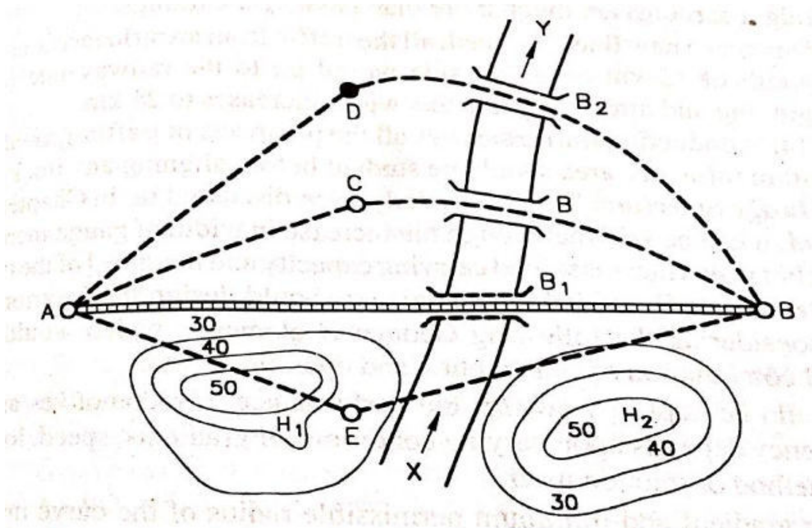


Fig. 13.1. Alternatives for Track Alignment.

b) Points through which a track should not pass:

a. Costly land

b. Religious places like temple, church, mosque or tomb

c. Areas liable to flooding (water logged areas), marshy areas etc.

2) **Traffic:** Growth of traffic, its position, nature and amount have to be considered. The position of traffic affects control points, the nature of traffic (passenger or goods) and its volume govern type of construction. General considerations are:

a) Traffic varies with square of population. Route with highest population is the best.

b) Freight earnings are much more than passenger earnings.

c) Influence area of railway line increases from 15 km to 25 km over a few years.

3) **Gauge selection:** increase in width of gauge increases initial cost but it also increases load carrying capacity and speed of trains.

4) **Geometric standards:** Some points to be considered are:
   - Ruling gradient and minimum radius should be considered
   - long lengths of straight portion should be provided in between two reverse curves
   - curves should be avoided at bridges, stations etc.
   - effect of rise and fall of ground should be considered

5) **Topography:** If topography of country is such that use of steep gradients is unavoidable, then in such cases the alignment of the track is made by the special ways to reducethe rate and cost of high gradients. For alignment, topography can be classified as:
   a) Valley alignment
   b) Cross country alignment
   c) Mountain alignment

6) **Economy:** different alignments are analysed from cost point of view and best alignment which gives maximum annual return is selected.

$$Annual.return = \frac{Gross.revenue - Annual.running.\exp enses}{Investment}$$

7) **Other considerations:**
   a) Geological formation should be studied
   b) Effect of flood and climate should be studied
   c) Track should cross road at right angles
   d) Station sites should be on level ground
   e) Availability of construction materials
   f) Political considerations such as avoiding foreign country.

RAILWAY SURVEYS

The various engineering surveys which are carried out for the choice of route of a new railway line can broadly be divided into the following categories:

1) Reconnaissance survey
2) Preliminary survey
3) Location survey
4) Railway electrification survey

1) Reconnaissance survey:

Main objectives are:

1) to obtain general knowledge of the whole territory
2) To obtain information regarding the salient features of the territory

Importance of reconnaissance survey: A number of possible alternative routes between two points can be worked out. Personal factors play an important role in the reconnaissance survey. The successful conduct entirely depends on the personal qualities of the engineer such as his training and experience, his capacity of observation and interpretation.

Information gathered in reconnaissance survey: A reconnaissance survey can broadly be divided into two categories:

1. Traffic reconnaissance survey
2. Engineering reconnaissance survey

Traffic reconnaissance survey: This consists of collection of the information regarding the following:

a) The general character of the country and the extent of cultivation;

b) Information regarding the local industries and religious festivals;

c) The general condition as regards prosperity of people in the locality and density of population and its distribution;

d) The probable amount of traffic to be served by new railway line;

e) The probable new traffic lines to be opened up to join large centres of trade;

f) Nature and volume of exports and their destination;

g) The amount of imports and centres of their distribution;

h) Possibilities of development of industries as a result of the new railway line;

i) Visiting all trade centres and consultation with prominent citizens and local authorities regarding the most suitable route for the railway;

j) Standard of construction required for carrying the probable traffic;

k) Study of the existing means of transport

Engineering reconnaissance survey: This consists of collection of information regarding the following:

a) Physical features of the country;

b) The surface formation of the ground;

c) Nature of soil and its classification;

d) Streams and rivers of the immediate vicinity, especially those which are likely to cross the proposed railway line;

e) Positions of hills and lakes;

f) Samples of water from wells, rivers, etc. so as to ascertain weather the water is suitable for use in locomotive or not;

g) Availability of materials and labour for use during construction.

3) Preliminary Survey:

Object of preliminary survey: To conduct survey work along alternative routes found out by reconnaissance survey and to decide most economical route. Thus, in preliminary survey, all the possible routes of railway line are critically studied, examined and analysed.

Importance of preliminary survey: It decides the final route and recommends only one particular route in preference to other alternative routes. Thus, it should be carried out with great precision as it affects the alignment of the final route.

4) Location Survey:

Object of location survey: The main object of location survey is to carry out the detailed survey along the route which has been found and fixed as the most economical route from the data of the preliminary survey.

Importance of location survey: Location survey establishes the central line of the actual track to be laid and hence as soon as the location survey is completed, the construction work is started. Thus, end of the location survey is the beginning of the actual laying of new railway line.

Work of location survey: It is carried out in two stages: 1. Paper location 2. Field location 1. Paper location: The final route selected is put up on paper and details such as gradient, curves, contours, etc. are worked out. All the working drawings are prepared, even of minor structures such as signal cabins. After the paper location is over, the field work is started and the centre-line of the track is fixed.

2. Field location: The field location transfers paper location on the ground. Moreover, It gives all the requirements of the construction engineer such as bench- marks, levels, measurements, etc. The centre-line pegs are driven at every 300 metres along the centre-line of the track.

Instruments for location survey:

Instruments used are theodolite, precise level and steel tape.

5) **Railway Electrification Survey:**

It is classified into two categories:

a) Cost cum feasibility survey; and
b) Foot by foot survey.

a) ***Cost cum feasibility survey:*** It is quick electrification survey for the proposed route to examine major engineering installations which may have a bearing on the cost of electrification. The scope of survey is as under:

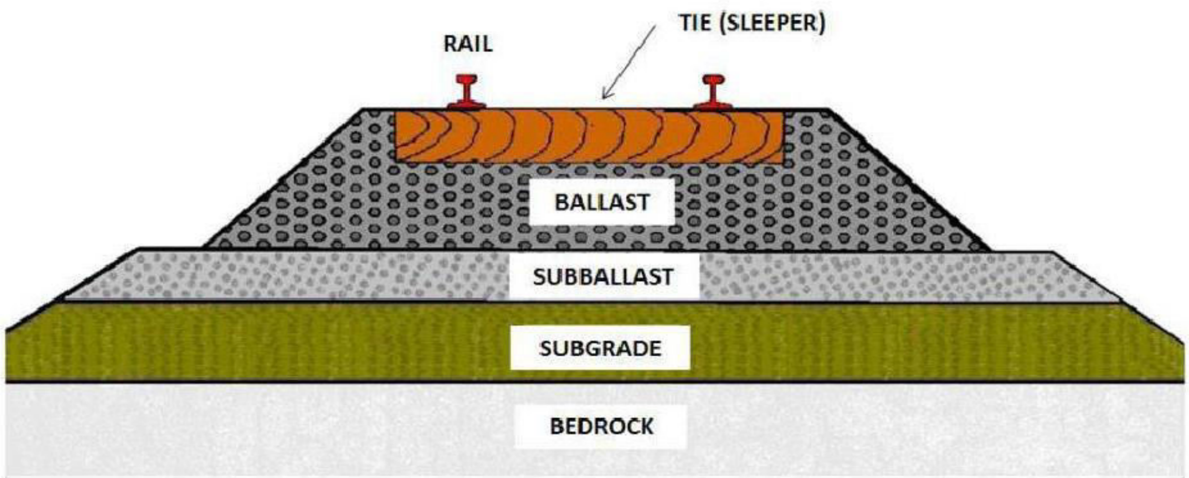
i) Civil works: It includes examination of heavy over line structures like flyovers, road over bridges etc and tunnels to find whether they require major or minor modification to permit erection of overhead equipment.
ii) Signalling and telecommunication works: It includes required modification to existing installations for General Power Supply.
iii) Modification to track crossings

b) ***Foot by foot survey:*** On acceptance of a project report, foot by foot detailed surveys are required for the preparation of working drawings for the electrification.

COMPONENT PARTS OF RAILWAY TRACK

The Typical components are:

a) Rails
b) Sleepers (or ties)
c) Fasteners
d) Ballast (or slab track)
e) Subgrade



Typical cross-section of railway track

a) **Rails**- The rails on the track can be considered as steel girders for the purpose of carrying axle loads.

b) **Sleepers** (or ties)- Members laid transverse to rails on which the rails are supported and fixed, to transfer loads from rails to ballast and subgrade below

c) **Fasteners**- these are used to keep rails in proper position

d) **Ballast** (or slab track)- Granular material, usually broken stone or brick, kankar, gravel or sand placed below and around sleepers to transmit load from sleepers to formation. It also permits drainage.

e) **Subgrade**- naturally occurring soil prepared to receive ballast, sleepers and rails for constructing railway track.

RAILWAY TRACK CROSS-SECTIONS

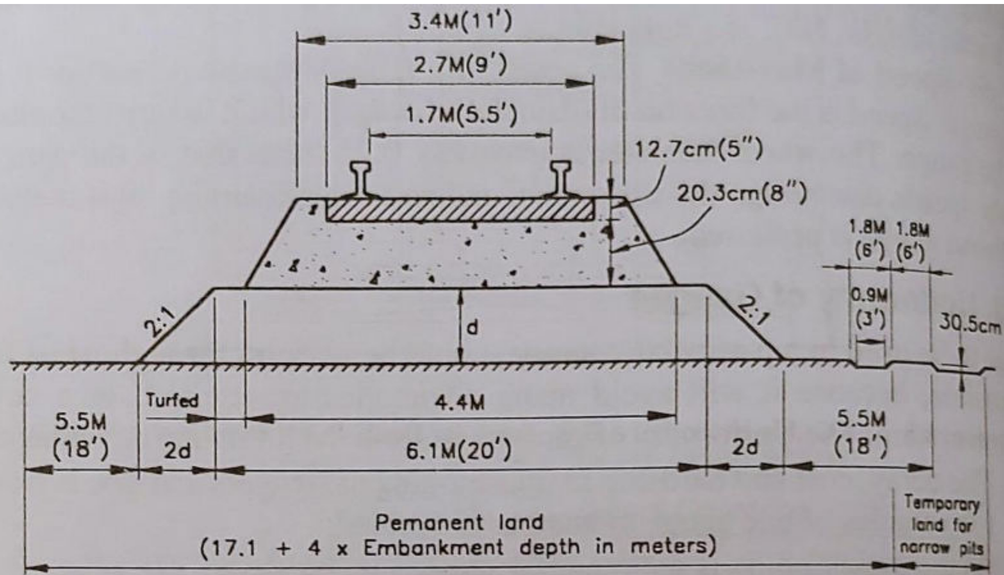


Fig. 3.2 The Cross-section of a B.G. Track in Embankment (on Straight Track)

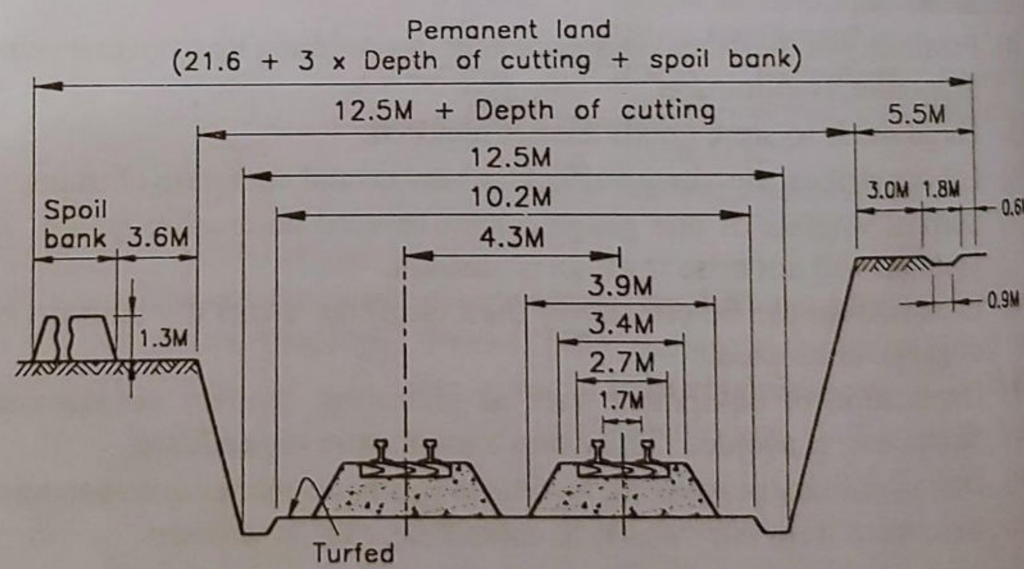


Fig. 3.3 The Cross-section of a B.G. Track in Cutting for Double Line (on Straight Track)

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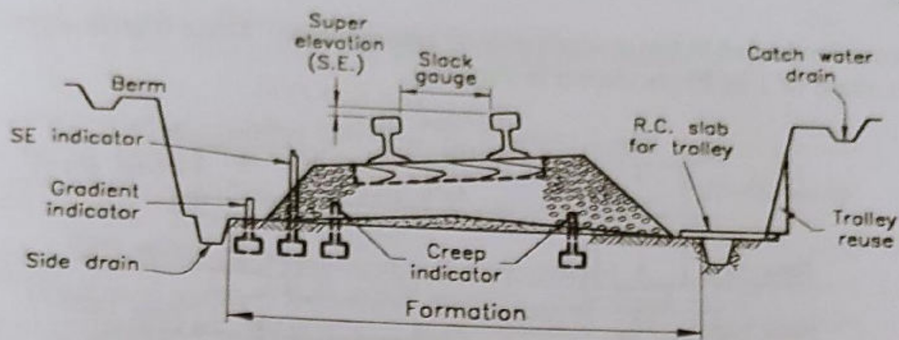


Fig. 3.4 The Cross-section of a B.G. Track for a Single Line (on Curved Track)

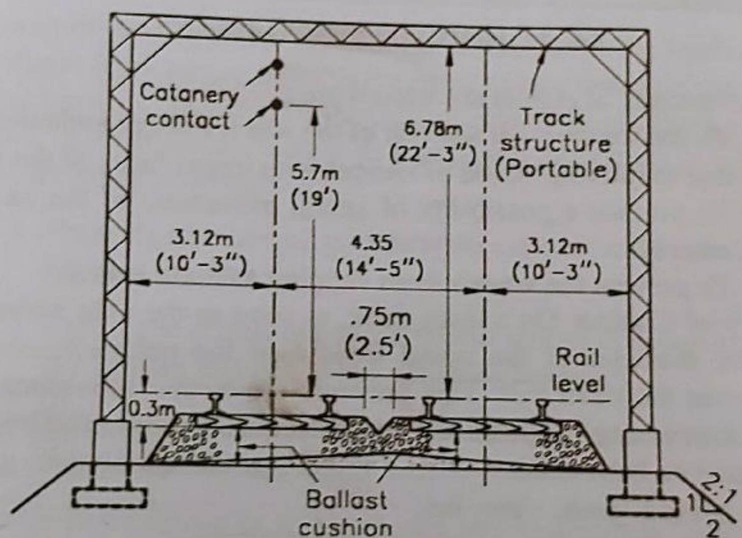


Fig. 3.5 The Cross-section of a B.G. Track for Double Line with Electric-traction

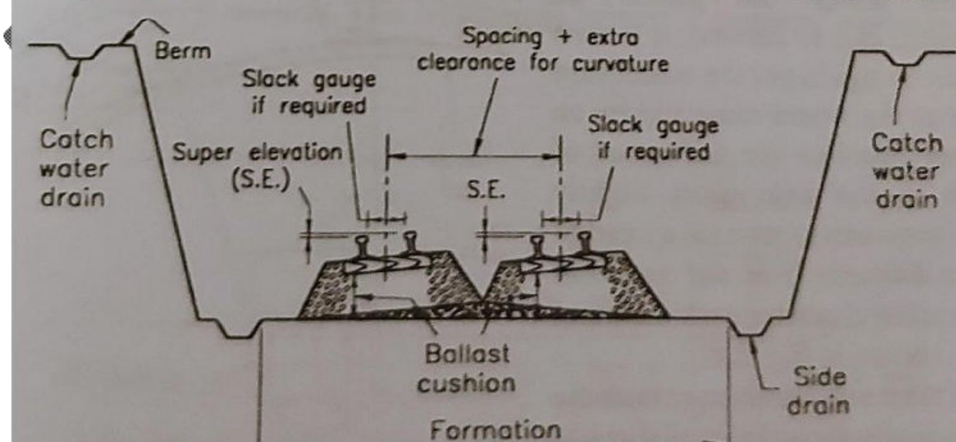


Fig. 3.6 The Cross-section of a B.G. Track for Double Line in Cutting (on Curved Track)

MODULE – 2 PERMANENT WAY

PERMANENT WAY (RAILWAY TRACK)

The completed track or a railway line is known as permanent way. The combination of rails fitted on sleepers and resting on ballast and subgrade is called the railway track or permanent way.

- Sometimes temporary tracks are also laid for conveyance of earth and materials during construction works. The name permanent way is given to distinguish the final layout of track from these temporary tracks.

Requirements of an ideal permanent way

1. The gauge should be correct and uniform.
2. Minimum friction between wheels of the train and rails.
3. The rail should be in proper level. In a straight track – two rails must be at the same level. On curves – the outer rails have proper superelevation and there should be proper transition at the junction of a straight and curve.
4. Adequate provisions for easy renewals and replacements.
5. Track should be strong, low in initial cost as well as maintenance cost.
6. Track should be resilient and elastic in order to absorb shocks and vibrations of running track.
7. Gradient should be even and uniform.
8. Track should have enough lateral strength
9. Drainage facility should be perfect.
10. Precautions to avoid occurrence of creep
11. The alignment should be correct, i.e., it should be free from kinks or irregularities.

Capacity of a railway track

Capacity of a railway (track capacity) is the hourly capacity of the track to handle the trains safely or in other words it is the number of trains that can be run safely on a track per hour.

Gauges in railway track

Gauge:- Clear distance between inner or running faces of two track rails. The distance between the inner faces of a pair of wheels is called the "**wheel gauge**".

Different Gauges in India

	Type of gauge	Gauge width
1.	Standard Gauge or Broad Gauge(B.G.)	1.676 m
2.	Metre Gauge (M.G.)	1.0m
3.	Narrow gauge (N.G.)	0.762 m
4.	Light Gauge (L.G.)	0.610 m

Selection of Gauge

1. **Cost of construction** – There is little increase in the initial cost if we select a wider gauge due to the following reasons.
    a. The cost of bridges, tunnels, station buildings, staff quarters, signals, cabins and level crossings is the same for all the gauges.
    b. The cost of earth work, ballast, sleepers, rails, etc. would proportionally increase with increase in gauge width.
2. **Volume and nature of Traffic** – Greater traffic volume and greater load carrying capacity, the trains should be run by a better traction technique or by better locomotives. For heavier loads and high speed, the wider gauges are required.
3. **Development of the areas** – Narrow gauges can be used to develop the thinly populated areas by joining the under developed areas with developed or urbanised areas.
4. **Physical features of the country** – Use of narrow gauge is warranted in hilly regions and in plain also when high speed is not required and the traffic is light N.G. is the right choice.

5. **Speed of movement** – the speed of train is almost proportional to the gauge. Speed is the function of wheel diameter which in turn limited by the gauge. The wheel diameter is generally 0.75 times that of the gauge.

Uniformity of Gauges

Gauge to be used in a particular country should be uniform throughout as far as possible. The uniformity of gauges results in the following advantages:

1. The delay, cost and hardship in transhipping passengers and goods from the vehicles of one gauge to another is avoided.
2. As the transhipping is not required, there is no breakage of goods.
3. Difficulties in loading and unloading are avoided and labour expenses are saved.
4. Large sheds to store goods are not required.
5. Surplus wagons of one gauge cannot be used on another gauge. This problem will not arise if gauge is uniform.
6. Locomotives can be effectively used on all the tracks if a uniform type of gauge is adopted.
7. During military movement, no time is wasted in changing personnel and equipment from one vehicle to another if gauge is uniform.

RAILS

The rails on the track can be considered as steel girders for the purpose of carrying axle loads.

- Rails are made of high carbon steel to withstand wear and tear
- Flat footed rails are mostly used in railway track.

Functions of rails

1. It should bear stresses developed due to heavy axle vertical loads, lateral and braking forces and thermal stresses.
2. To provide a hard and smooth and unchanging surface for passage of heavy moving loads with a minimum friction between the steel rails and steel wheels.

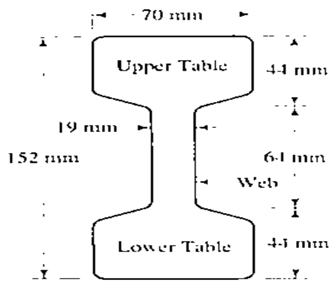
3. Transmit load to sleepers and consequently reduce pressure on ballast and formation below.
4. The rail material used is such a way that it gives minimum wear to avoid replacement charges and failures of rails due to wear.

Requirements of rails

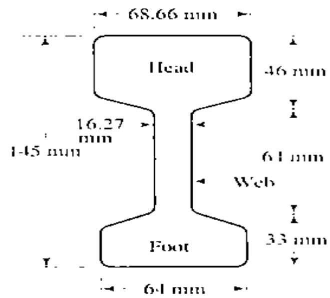
1. The bottom of head and top of foot of rails should be so shaped as to enable the a fish plates to transmit the vertical load efficiently from the head to the foot at rail joints.
2. The centre of gravity of rail must lie approximately at the mid height of rail, so that maximum tensile and compressive stresses are almost same.
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. Web of rails should be sufficiently thick to bear the load coming on it and should provide adequate flexural rigidity in horizontal planes.
6. Foot should be wide enough so that rails are stable against overturning, especially on curves.
7. The tensile strength of the rail piece should not be less than 72 kg/m^2

Types of Rail sections

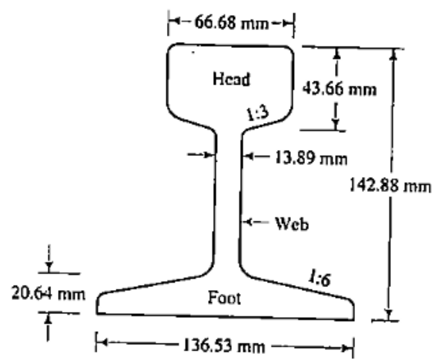
1. Double headed rails (D.H. rails)
2. Bull headed rails (B.H. rails)
3. Flat footed rails (F.F rails)



Double headed rail



Bull headed rail



Flat footed rail

- In the beginning, the rails used were double headed (D.H.) of a dumb bell section. The idea behind using of these rails was that when the head was worn out in course of time, the rails can be inverted and reused.
- Experience showed that such indentations are formed in lower table due to which smooth running over that surface at the top was impossible.
- Next evolution was that of a bull headed (B.H.) rails, in which the head was made little thicker and stronger than the lower part, by adding more metal to it, so that even after wear, it can withstand stresses.
- Side by side with the B.H. rails, flat footed rails were developed. It was originally thought that flat footed rails could be fixed to sleepers directly and would eliminate the need for chairs and keys required for the B.H rails

- But, it was observed that heavy train loads caused the foot of the rails to sink in to the wooden sleeper, making the spikes work loose. To remedy this steel bearing plates are introduced, between the sleeper and rail
- In India, flat footed rails are commonly used

Flat Footed rails (F.F rails)

Merits:-

1. They have more strength and stiffness both vertically and laterally than B.H. rails
2. No chairs and keys are required.
3. Fitting of rails with sleepers are simpler, so they can be easily laid and re laid.
4. In points and crossings the arrangements are simpler than B.H. rails.

Demerits:-

1. The fitting get loosened more frequently than in case of B.H. rails
2. The strengthening of bent rails, replacing of rails and de hogging of battered rails are difficult.

Bull headed rails (B.H. rails)

Merits:-

1. The rails are easily disconnected from sleepers as they have no direct connection with the latter.
2. The heavy chairs with larger bearing on sleepers give longer life to wooden sleepers and greater stability to the track.

Demerits:-

1. They have less strength and stiffness
2. They require heavy maintenance cost.

Selection of rails

A rail designated by its weight per unit length. Various factors considered in deciding weight of rails are

1. Speed of trains
2. The gauge of track

3. The axle load and nature of traffic
4. Type of rails
5. Spacing of sleepers

Length of rails

The rails of larger length are preferred to smaller length of rails, because they give more strength and economy for a railway track. The length of rail is governed by the following factors.

1. Length of the rail is so chosen that the manufacturing cost is most reasonable.
2. It depends upon the transportation facilities, so only those lengths of rails are possible which can be transported by longest wagons available on the railways.
3. More length of the rail, more will be the gap required for expansion of rails.

Corrugated and roaring rails

- In some places, the heads of rails are found to be corrugated rather than smooth and straight, when the vehicles pass over such rails, a roaring sound is created.
- The corrugations consist of minute depressions on the surface of rails.
- They are usually created at places where either brakes are applied or trains are start.

FAILURE OF RAILS

Factors influencing

- Axle load of locomotive
- Constant reversal of stresses
- Defects in manufacture
- Design of rail joints
- Rail length
- Rail quality
- Rail section
- Rail welding
- Speed of trains

<u>Types of rail failures</u>

- **Crushed head**
- **Transverse fissure**
- **Split head**
- **Horizontal fissure**

WEAR OF RAILS

Wear of rails is caused by the movement of a number of wheels of the vehicle.

Classification of wear based on location:

1. **Wear on the top or the head of rail:**

   The metal from the top of the rail flows and form projections known as burs. The causes for this type of wear include:

   - Rails worn out due to abrasion of rolling wheels over it.
   - Heavy wheel loads concentrated on very small area resulting in flow of metal from top.
   - Impact of heavy loads.
   - Grinding action of sand particles between rails and wheels.
   - Corrosion action of metal rails, especially near sea.
   - Metal on top starts burning during starting or when brakes are applied to moving trains.

2. **Wear of rails at the end of the rail** :

   It is much greater than wear on the top

   Cause

   The blow imparted to the ends of the rails during the jumping of wheels of the vehicles at the expansion gap.

   Effects

   1. The fish plate and fish balls become loose
   2. Contact surface between rails and sleepers get worn out.

3. Sleepers at the expansion joint are depressed due to the settlement of ballast at these points.

3. Wear of rail on the sides of the head of rail

This is the most destructive type and occurs on tracks laid on curves.

Causes

1. Due to the curvature, the pressure due to centrifugal force cause grinding action of wheel flanges on the inner side of the head of outer rail.
2. Vehicles do not bend to the shape of the curvature while moving over a curve and this results into the biting of the inner side of head of outer rail by the wheel flanges
3. Slipping action of the wheel on the curves.

Methods to reduce the wear of rails

- Use of special alloy steel
- Good maintenance of track
- Reduction of expansion gap
- Exchange of inner and outer rail on curves.
- Introducing check rails all the way round the inner rail and parallel to it.
- Use of lubricating oil.
- Use of head hardened rails

  (allowing the rail to pass through an isometrical treatment plant)

Measuring wear of rails

Following are the two methods for measuring wear:

- Rail is removes and its weight is measured. Compare it with original weight. Prescribed permissible limit of wear in India is 5%.
- A correct profile of head of rail is obtained by suitable equipment and this is compared with the profile of new rail.

CREEP OF RAIL

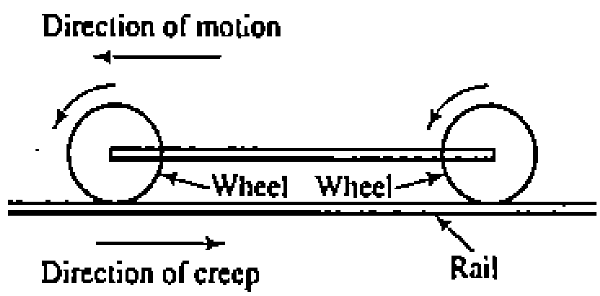
The longitudinal movement of rails in a track is known as creep. The value varies from 0-130 mm per month. Creep can be noted by

1. Closing of successive expansion spaces at rain joints in the direction of creep.
2. Opening out of joints at the points from where the creep starts.
3. Marks on rail flanges and webs made by the scratching as the rails slide.

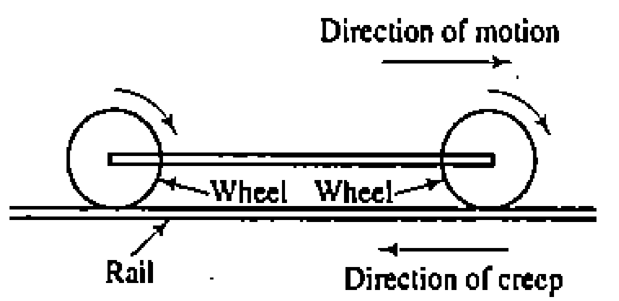
Causes of Creep

I. **Brakes**

The creep is developed due to forces that come into action when the train is starting or stopping by application of brakes. During starting operations, the wheels push the rails backward and during stopping operations, the wheels push the rails forward.



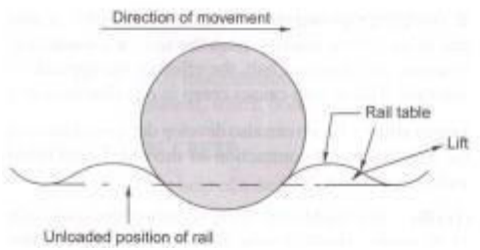
Creep during starting
FIG. 11-1



Creep during stopping

II. **Wave Theory / Wave Action**

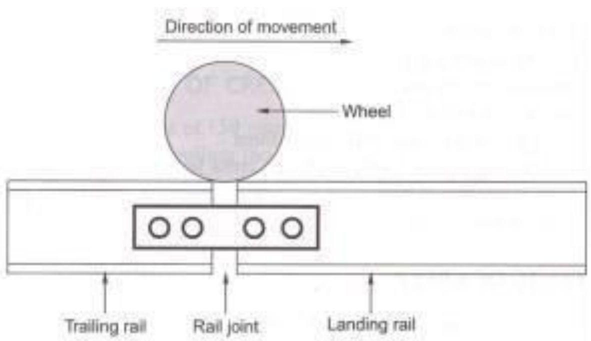
The creep is developed due to the wave motion of wheels on rails. Due to the movement of the wheel loads on the rail, the rail deflects as a continuous beam and crests are formed at the supports. When the wheels of the vehicle strike against these crests, creep is developed.



III. **Percussion theory**

According to this theory, impact of rail wheel ahead of the joints gives rise to the creep in rails.

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 wheels passing over the joint pushes the facing or landing rail forward, thereby causing creep.



IV. **Changes in temperature**

Creep may also develop due to unequal expansion and contraction of rails owing to the changes in temperature. The creep is more rapid during hot weather.. And also influenced by variation of location of track(exposed track or track in shady surroundings)

V. **Unbalanced traffic**

In single line system if heavy traffic runs in both direction creep is almost balanced .otherwise (heavy traffic only in one direction) will cause creep.

Measurement of Creep

Creep can be measured with the help of a device called creep indicator. It consists of two creep posts, which are generally rail pieces that are driven at 1 km intervals on either side of the track. For the purpose of easy measurement, their top level is generally at the same level as the rail. Using a chisel, a mark is made at the side of the bottom flange of the rail on either side of the track. A fishing string is then stretched between the two creep posts and the distance between the chisel mark and the string is taken as the amount of creep.

Methods of correcting creep

1. **Pulling back of the rail method:** rails are pulled back equal to the amount of creep, either by manpower or with the help of jacks.
2. **Use of creep anchors:** creep anchors consist of cast-iron pieces which are made to grip the rail. These are placed behind the sleepers for every third or fourth sleeper. This arrangement prevents the movement of the rails because the sleepers which are embedded in the ballast will also have to move, if creep has to take place.
3. **Use of steel sleepers:** Steel sleepers are provided with fittings which donot easily allow the creep to occur and they also have a good grip with the ballast to resist their movement in the ballast.

<u>KINKS IN RAILS</u>

The lateral movement of ends of the rails out of its original position is called kinks.

Causes of formation of kinks are:

1) Loose packing at joints
2) Defect in gauge and alignment

3) Defect in cross level at joints
4) Uneven wear of rail head, where kinks are formed at joints

Kinks produce the following undesirable effects:

1) Cause unpleasant jerks in vehicles
2) Due to uneven wear of rail heads, kinks appear at places other than the joints and obstruct smooth running of trains.
3) A series of kinks are seen at curves due to which defect in gauge, alignment and camber may occur. This sometimes causes serious risk in turning operations of trains.

Measures to remove kink include:

1) Correcting alignment at curves and joints
2) Proper packing at joints
3) Proper maintenance of track periodically in respect of cross levels, gauge, alignment, welding of worn out portions etc.

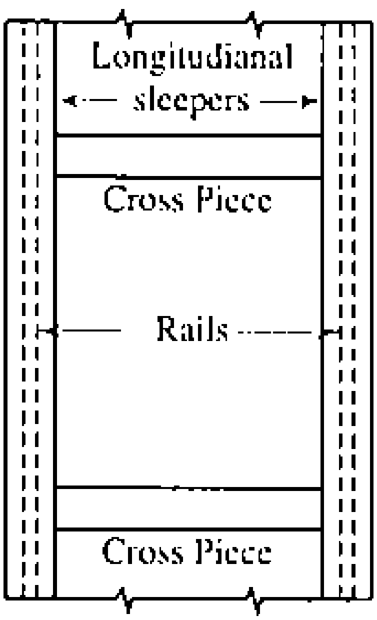
SLEEPER

Functions of sleeper

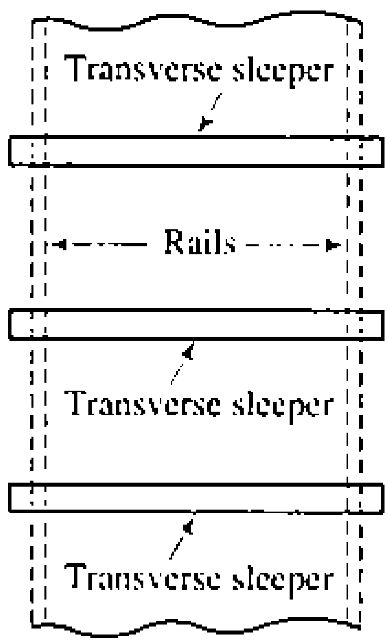
1. It should support the rails firmly and evenly.
2. Maintain the gauge of the track correctly
3. Distribute the weight coming on the rail over a sufficiently larger area of the ballast.
4. To act as an elastic medium between the rails
5. Help the easy replacement of rails fastenings , without seriously disturbing the traffic.
6. Permit insulation of the track for electrical sections.
7. Maintain the track at proper grade.
8. Maintain the alignment of the track

Types of sleepers

1. **Longitudinal sleepers:** it is the earliest form and consists of slabs of stones or pieces of timber placed parallel to the rails. Cross pieces were provided at intervals to maintain the correct gauge of track. This type of sleepers is discarded now since the running of train is not smooth, cost is more and noise created is more.
2. **Transverse sleepers/ cross sleepers:** First introduced in Britain in 1835. Sleepers are placed at right angles to rails. They are universally adopted and remove disadvantages of longitudinal sleepers.



Longitudinal sleepers



Transverse sleepers

Requirements of Sleeper

1. Initial and maintenance cost should be as low as possible.
2. Fastening should not be complicated in design.
3. Weight of sleeper should be moderate.
4. Sleeper should possess sufficient bearing area below rail seat and over ballast.
5. Sleeper should be such that it is possible to readjust and maintain the gauge correctly.
6. Should be capable to resist to shocks and vibrations due to fast moving vehicles.

7. Sleeper material should not interfere with the working of track circuits.
8. Sleepers should not break during the packing of the ballast.
9. It should not move forward during the passage of trains.
10. It should possess antitheft quality.
11. It should withstand derailment without excessive damage.
12. Should be easy to manufacture, transport and lay.

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 metres 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 depth of 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 implies that 13 + 7 = 20 sleepers will be used per rail length of the track on that route. The number of sleepers in a track can also be specified by indicating the number of sleepers per kilometre 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. 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.

Materials for cross sleepers

Following materials are used for the cross-sleepers on the Indian Railways:

1) Timber or wooden sleepers

2) Steel sleepers
3) Cast-iron sleepers
4) Concrete sleepers

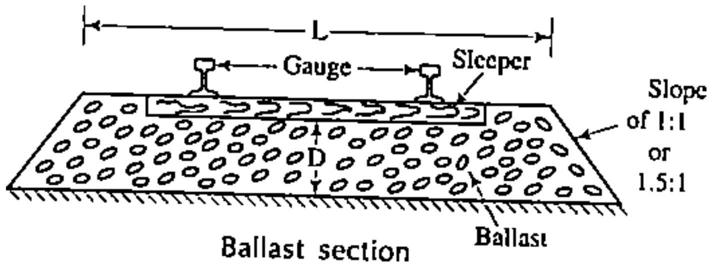
Comparison of different types of sleepers

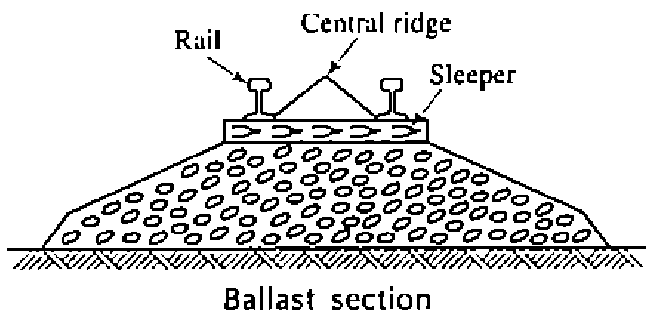
Characteristics	Type of sleeper			
	Wooden	Steel	'CI	Concrete
Service life (years)	12-15	40-50	40-50	50-60
Weight of sleeper for BG (kg)	83	79	87	267
Handling	Manual handling; no damage to sleeper while handling	Manual handling; no damage to sleeper while handling	Manual handling; liable to break by rough handling	No manual handling; gets damaged by rough handling
Type of maintenance	Manual or mechanized	Manual or mechanized	Manual	Mechanized only
Cost of maintenance	High	Medium	Medium	Low
Gauge adjustment	Difficult	Easy	Easy	No gauge adjustment possible
Track circuiting	Best	Difficult; insulating pads are necessary	Difficult; insulating pads are necessary	Easy
Damage by white ants and corrosion	Can be damaged by white ants	No damage by white ants but corrosion is possible	Can be damaged by corrosion	No damage by white ants or corrosion
Track elasticity	Good	Good	Good	Best
Creep	Excessive	Less	Less	Minimum
Scrap value	Low	Higher than wooden	High	None

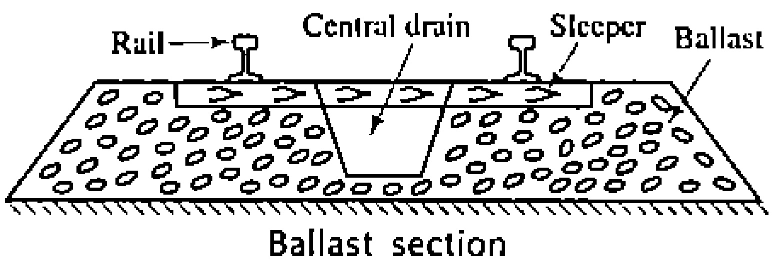
<u>BALLAST</u>

Functions of Ballast

1. To provide a hard and level bed for sleepers to rest on
2. To hold the sleepers in place during the passage of trains
3. To transmit and distribute the load from the sleepers to the formation.
4. To allow for maintaining correct track levels.
5. To protect the surface of formation from the direct exposure to sun, frost or rain
6. To form an elastic bed
7. To drain the water immediately and keep the sleepers in dry condition.
8. To discourage the growth of vegetation.
9. To resist the lateral , longitudinal and vertical displacement of the track







Requirements of Ballast

1. It should be possible to maintain the required depth of the material in order to distribute uniformly the weight of passing train on the ground
2. The nature of the ballast material should be such that it should provide sufficient grip to sleepers to prevent their horizontal movement.
3. Material should be elastic in nature.
4. The ballast material should not be brittle, but should possess sufficient compressive strength.
5. Should not allow rain water to accumulate.
6. Should be cheap and easily available.
7. Should not have any chemical action on rails and sleepers.

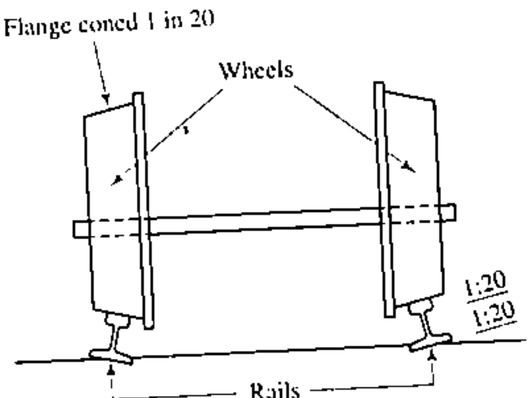
8. Easily workable and should be durable.

CONING OF WHEELS

The flanges of the wheels are not made flat but it is in the shape of cone with a slope of about 1 in 20. As the wheels are set on the axle there is some chance for that lateral movement between the flanges of the wheels and the rails. So without coning, the flanges would cause a slight but sudden shock to the sides of the rails. Thus the coning of wheels is mainly done to maintain the vehicle in the centre position with respect to the track.

Behaviour of the coned wheels on straight level track

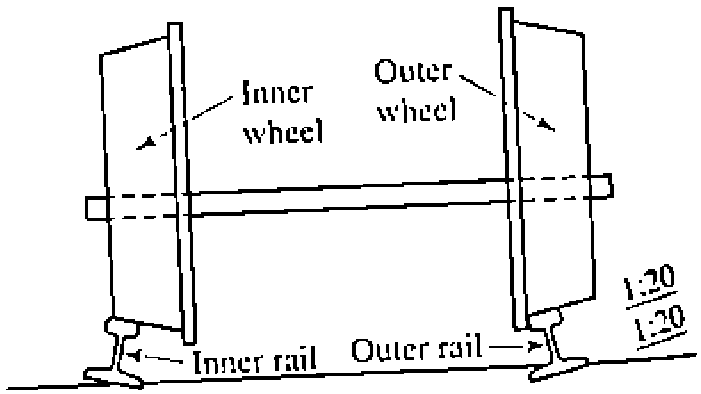
On straight and level tracks the flanges of the wheel have equal circumferences.



Behaviour of coned wheels on level track

Behaviour of the coned wheels on curved track

When the wheels move along a curve, the outer wheel has to cover a greater distance than that of inner rail. The vehicle also has a tendency to move sideways towards the outer rail, the circumference of the flange of outer wheel will be greater than that of inner wheel. This will help the outer wheel to cover a longer distance than the inner wheel.



Behaviour of coned wheels on curves

Disadvantages of Coning of Wheels

1. Smooth riding is produced by the coning of wheels, but the pressure of the horizontal component near the inner edge of the rail has a tendency to wear the rail quickly.
2. The horizontal component tends to turn the rail outwards and hence the gauge is sometimes widened.
3. If no base plates are provided, the sleepers under the outer edge of the rail are damaged.

These can be overcome by tilting of rails. i.e. the rails are not laid in flat. They are tilted inwards. Tilting of rail is made by the use of inclined base plate, i.e. the slope of the base plate is 1 in 20, same as the slope of the coned surface of the wheel.

Advantages of tilting of rails

1. Uniform wear of the head of rail
2. Maintain the gauge properly
3. Increase the life of rails and sleepers.

BALLASTLESS TRACK

Ballastless track or slab track is a type of railway track in which the traditional elastic combination of ties/sleepers and ballast is replaced with a rigid construct of concrete or asphalt.

In ballastless track, the rails are rigidly fastened to a special type of concrete ties/sleepers that are themselves set in concrete. Ballastless track therefore offer a high consistency in track geometry, the adjusting of which is not possible after the concreting of the super structure. Therefore ballastless track must be concreted within a tolerance of 0.5 mm.

Advantages of ballastless track:

- Highly consistent track geometry
- Larger life span
- Reduced need for maintenance
- Fewer deformations and smooth running
- Better and controlled drainage
- Easier to clean

Disadvantages of ballastless track

- High cost of initial construction
- Impossibility of adjusting or correcting track geometry once concrete has been set
- Necessity of stable infrastructure since no adjustments can be made to the super structure
- Higher noise emissions
- Longer repair times when the concrete slab is damaged

RAIL FASTENINGS

A joint is made between two rails and this incidentally forms the weakest part of the track. Many fastenings are found out to make this joint as much efficient as much possible.

Requirements of an ideal rail fastening

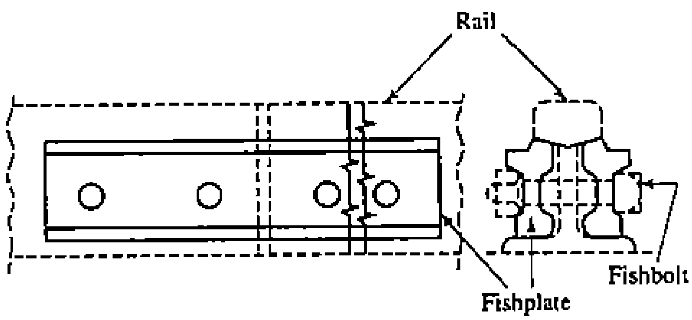
1. Should be capable of absorbing shocks and vibrations.
2. Should give protection to sleeper against action of horizontal and vertical forces.
3. Should give sufficient insulation in case of electrified sections.
4. Should resist creep
5. Should be capable of securing gauge at first assembly and maintain gauge.
6. Should be cheap
7. Should consist of less number of components
8. Should be durable
9. Should be easy to fix and adjust
10. Should be non corrosive
11. Should have sufficient strength to resist damage due to derailment
12. Should be designed to remove only by special tools
13. Should keep rail in correct position, level and alignment
14. Should not affect the rail or sleeper adversely in any respect
15. Should not be too rigid
16. Should possess adequate strength to resist lateral forces
17. Should possess high torque resistance

Types of fastenings

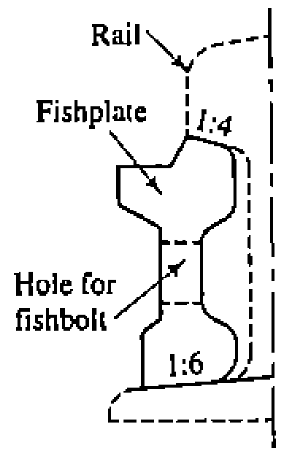
- Fish plates
- Spikes, Fang bolts and hook bolts
- Chairs & keys
- Bearing plates

FISH PLATES

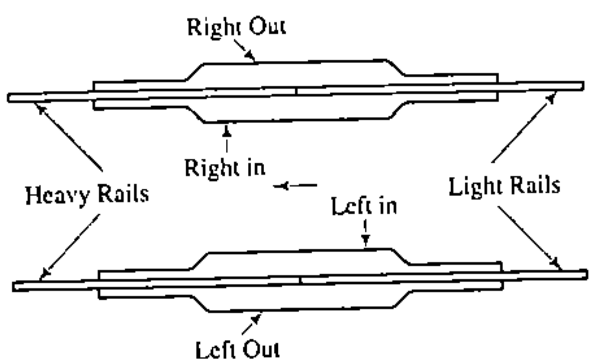
Rails at the ends are connected by a pair of fish plates per rail and joint using fish bolts and nuts. In India we use 4 fish bolts and length of fish plate should not be less than 457mm (4457mm). Fish plates are provided between the bottom of head of rail and top of foot of rail. The shape of the fish plate is given so that they do not come into contact with the web of rail.



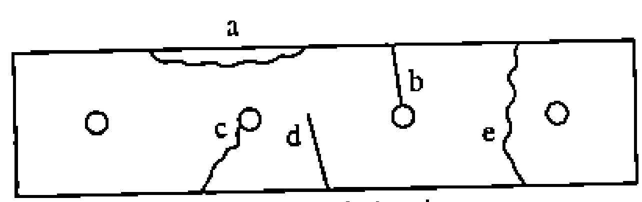
Connection of two 45 *R* rails by fish-plates



Section of fish-plate for 45 *R* rails



Compound fish-piate



Failures of fish-plates

SPIKES, FANG BOLTS AND HOOK BOLTS

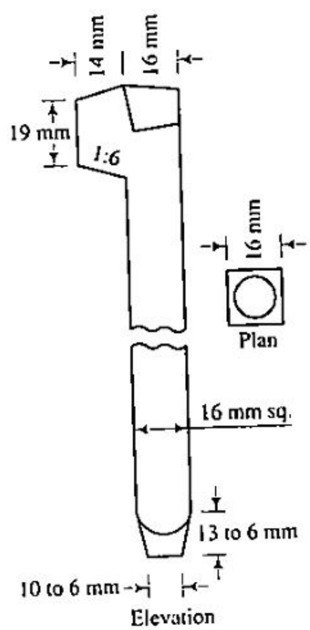
Spikes are used to hold the rails to the wooden sleepers. They can be used with or without bearing plates below the rails.

A good spike should fulfill the following requirements:

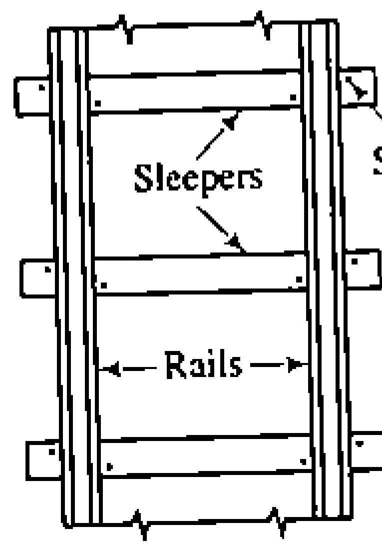
1. Hold the rail in position
2. It should be cheap
3. Easily fixed and removed
4. Properly maintain the gauge.

Types of spikes

- Dog spikes: Section of spike is square and lower end is blunt, pointed or chisel-shaped.



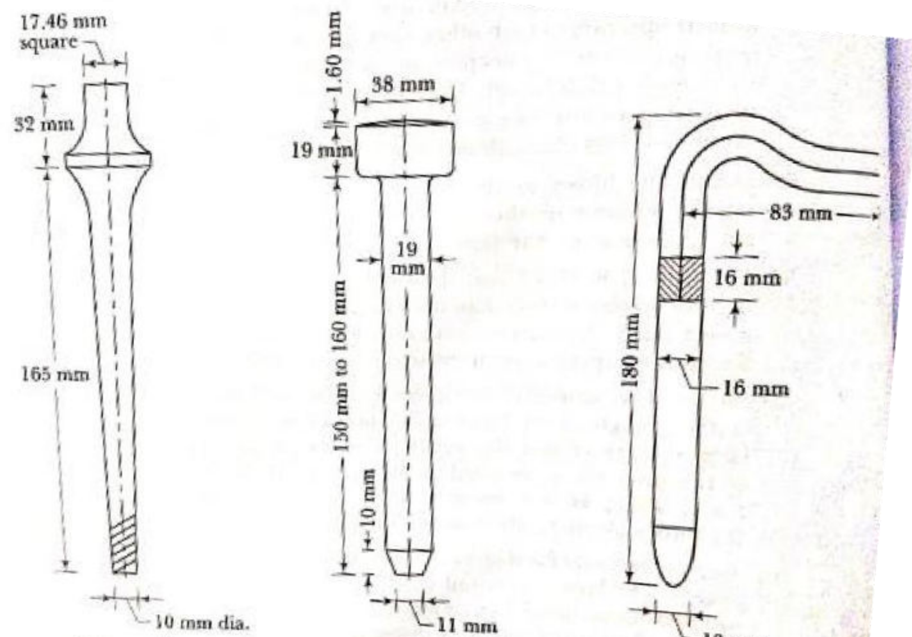
Dog-spike



Arrangement of dog-spikes

- Screw spikes/ coach screws: holding power is double that of dog spike. The head is circular with square projection. The sides are tapered and provided with threads. It resists lateral thrust better than dog spike, but is costly.
- Round spikes: These spikes have blunt ends and length varies according to the gauge.

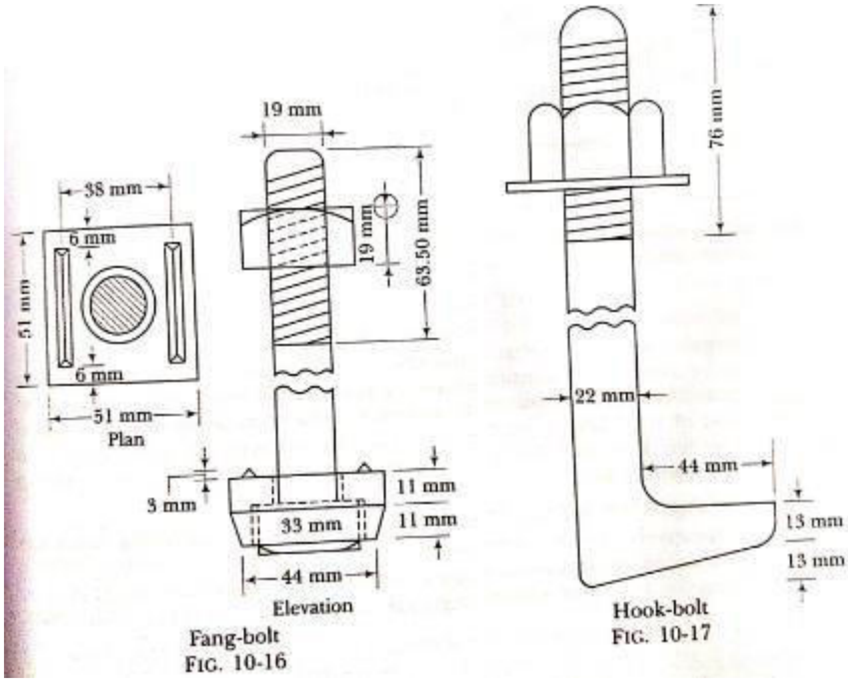
- Elastic spikes: S steel spring and specially shaped head are provided in these spikes. These provisions give a better grip with the foot of the rail and it results in reduced wear and tear of rail, less noise and less creep.



Screw-spike
FIG. 10-13
Round-spike
FIG. 10-14
Elastic-spike
FIG. 10-15

Fang bolts are used as alternative to round spikes. They are more effective but difficult to fix and remove. So they are not commonly used.

Hook bolts are used to fix the sleepers to girders of the bridges. The rails are as usual fixed with sleepers by means of dog spikes or screw spikes. The holes are bored in sleeper and the head of the hook-bolt grips with the flange of the girder. Two hook bolts are adequate for each sleeper.



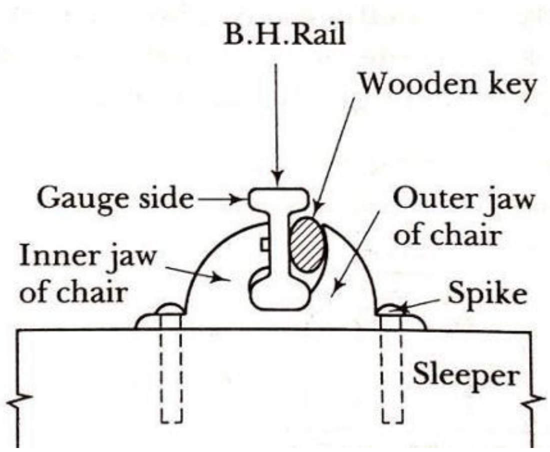
Fang-bolt
FIG. 10-16

Hook-bolt
FIG. 10-17

CHAIRS & KEYS

Chairs are used to hold the rails (double headed and bull headed) in position. It is made of cast iron. It is used to distribute the load from the rails to the sleepers. It consists of two jaws and a rail seat. The web of the rail is tightly held against the inner jaw of the chair and a key is driven between rail and outer jaw of chair.

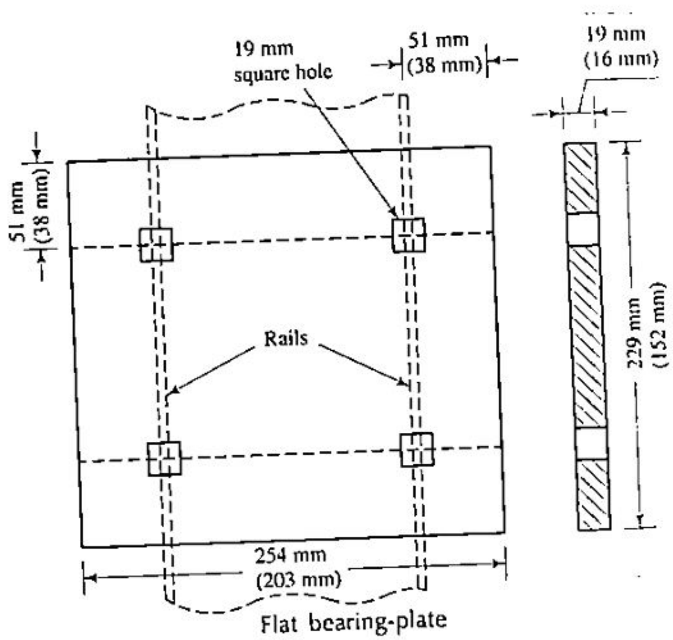
Key is used to keep the rail in proper position. Key may be made of wood or metal and they may be either straight or tapered. Common metal used for making key is steel.



BEARING PLATES

Bearing plates are the chairs for flat footed rails. It made of cast iron, rot iron or steel. The bearing plates may be either flatted or canted (given in a slope). As turnouts do not have any cant, flat bearing plates are provided under the sleepers.

Canted bearing plates, a cant of 1 in 20 corresponding to tilting of rail is incorporated and have a recess in the middle of the rail seat to prevent rocking of the rail in its seat.



GEOMETRIC DESIGN OF RAILWAY TRACK

A railway track on a straight is an ideal condition. But the curvature is to be provided invariably on railway track due to various reasons such as connecting important points, avoiding obstructions etc.

Geometric design of a railway track discusses all those parameters which affect the geometry of the track. These parameters are as follows:

1. Gradients in the track, including grade compensation, rising gradient, and falling gradient

2. Curvature of the track, including horizontal and vertical curves, transition curves, sharpness of the curve in terms of radius or degree of the curve, cant or superelevation on curves, etc.

3. Alignment of the track, including straight as well as curved alignment.

It is very important for tracks to have proper geometric design in order to ensure the safe and smooth running of trains at maximum permissible speeds, carrying the heaviest axle loads. The speed and axle load of the train are very important and sometimes are also included as parameters to be considered while arriving at the geometric design of the track.

Types of curves

Broadly divided as

- Horizontal curves: provided for smooth change in direction
- Vertical curves: provided when a rising gradient is followed by falling gradient or vice-versa or when a rising or falling gradient is increased or decreased.

General classification of curves

- Simple curves
- Compound curves
- Parabolic curves
- Transitional curves

Designation of curves

Curves on the railways are generally circular i.e. such curve should have same radius on every portion of it. A simple curve is either designated by its degree or by its radius. The degree of a curve (D) is the angle subtended at its centre by a 30.5 m or 100 ft arc.

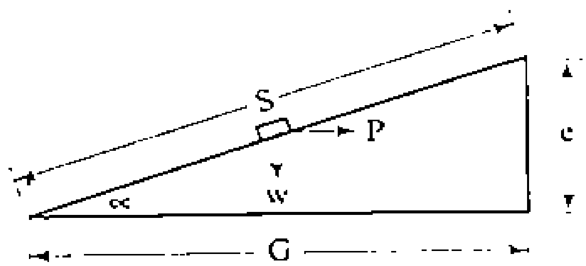
$$D = {}^{1720}/_{R}$$

R= radius in m

For 1^0 curve R = 1720m

SUPER ELEVATION

When a train moves round a curve, it is subjected to centrifugal force acting radially away from the centre of the curve. To counteract the effect of centrifugal force, the level of the outer rail is raised above the inner rail by a certain amount to introduce the centripetal force. Thus the elevation of outer rail above the inner rail at a horizontal curve is known as super elevation or cant.



Super-elevation

W= weight of moving train

P= Centrifugal force

G= Gauge of track in m

e= Super elevation in cm

α=Angle of inclination

S= Length of inclined surface

Objects of super elevation

1. Ensures smooth and safe movements of passengers and goods on track
2. To introduce centripetal force to counteract the effect of centrifugal force and hence faster movement of trains on curves is permitted.
3. It prevents derailment and reduces creep as well as side wear of rails.
4. To provide equal distribution of wheel loads on two rails and hence there will be no tendency of track to move out of position.
5. It results in decrease of maintenance cost of track.

$$e = \frac{GV^2}{1.27\,R}$$

e= super elevation in cm

V = speed in km/ hr

G = gauge in m

R = radius of curve in m

Maximum value of super elevation $= \frac{1}{10} gauge$

Maximum super elevation for broad gauge $= \frac{1}{10} x\ 1.67$ = 0.167m = 16.7 cm

Maximum super elevation for meter gauge $= \frac{1}{10} x\ 1$ = 0.1m = 10cm

Maximum super elevation for narrow gauge $= \frac{1}{10} x\ 0.76$ = 0.076 m = 7.6cm

Equilibrium Cant or equilibrium super elevation

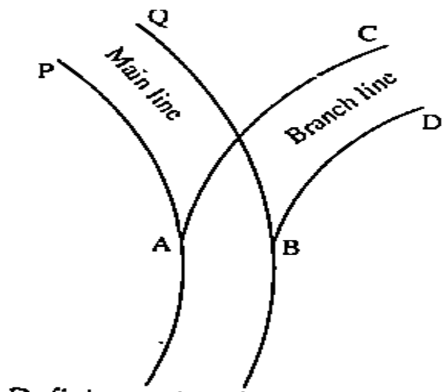
When the lateral forces and wheel loads are almost equal the cant is said to be in equilibrium.

Factors affecting super elevation

1) Frictional resistance: frictional resistance between rails and wheels will have some effect on super elevation.
2) Coning of wheels
3) Body of vehicle: in derivation of equation, body of vehicle is assumed to be rigid. But in actual practice, it is provided with compressive springs inorder to minimize the effect of impact.
4) Weighted average: super elevation is calculated only for a particular speed whereas in actual practice, different trains with different speeds will be travelling on track. Hence super elevation should be such as to accommodate these variations. Hence ***weighted average speed*** is taken.

Cant deficiency

Under certain circumstances it is not possible to provide the equilibrium cant. In the figure a branch line diverges from a main line.



Deficiency in super-elevation

AP & BQ are the inner and outer rails of the main line respectively and BD & AC are the inner and outer rails respectively of the branch line.

Let S_1& S_2 be the amount of super elevation required for main and branch lines respectively. The following conditions should be satisfied,

Considering main line, point B should be higher than point A by the amount S1.

Considering branch line, point A should be higher than point B by the amount S2.

But it is not possible to satisfy both the conditions simultaneously. Under such condition a small amount of deficiency in cant is permitted without correspondingly reducing the speed. This is known as cant deficiency or deficiency in super elevation. And it represents the difference between the equilibrium cant necessary for the maximum permissible speed and the actual cant provided as per average speed of trains.

In the above figure, instead of outer rails AC of branch line being higher; it is kept lower than the inner rail BD. Here the branch line curve has a negative superelevation.

Cant deficiency is limited due to following reasons:

1. Higher cant deficiency gives rise to higher discomfort to passengers.
2. Higher cant deficiency means higher will be the balanced centrifugal force and hence extra pressure and lateral forces on outer rails. This will require strong track and fastenings for stability.

Maximum deficiency in super elevation permitted in India

- 75mm and for speeds in excess of 100km/hr and with special permission up to 100mm for broad gauge
- 50mm for meter gauge and

- 40mm for narrow gauge.

Theoretical cant – actual cant = cant deficiency

SPEED OF TRAINS

In India, maximum speeds achieved by locomotives are as follows:

- For BG: 96 kmph
- For MG: 72 kmph
- For NG: 40 kmph

  With modernization of Indian Railways and use of electric traction, it has been now possible to attain train speeds upto 160 kmph on BG routes and upto 100 kmph on MG routes.

Speed of trains on curves

The safe speed of train while passing over a curvature depends on several factors such as gauge of train, super elevation, the provision or absence of transition curve, weight of trains etc. Hence various countries have developed certain empirical formula for obtaining the maximum speed.

The empirical formulas used in India are:

For B. G & M.G; $V = 4.4\sqrt{R-70}$

For N.G ; $V = 3.6\sqrt{R-6}$ with maximum value = 50 kmph

V = maximum speed in kmph

R = radius of curve in m

If transition curves is not provided then:

For BG and MG: speed = 0.80V.

For Narrow Gauge: speed= 0.80 V subject to a maximum of 40 kmph

GRADIENTS

The rate of rise or fall of the track is known as gradient. It is expressed as the ratio of vertical to horizontal, i.e. 1 in n or percent.

Gradients are provided to meet the following objectives:

(a) To reach various stations at different elevations

(b) To follow the natural contours of the ground to the extent possible

(c) To reduce the cost of earthwork

Types of gradients

The following types of gradients are used on the railways:

(a) Ruling gradient

(b) Pusher or helper gradient

(c) Momentum gradient

(d) Gradients in station yards

* Types of Gradients

The rate of raise or fall of the track is known as gradient. It is expressed as the ratio of vertical to horizontal ie $\frac{1}{n}$ or percent.

Types of:

1. Ruling or max gradient

It is the max gradient to which the track may be laid. It mainly depends on the loads of train and additional power of locomotive, because on gradients extra power is required to pull the train. Steeper the gradient, more will be the power required.

In India, In plains 1 in 150 to 1 in 200.
In hilly areas 1 in 100 to 1 in 50

2. Momentum gradient

On falling gradients, train gets momentum and this momentum can be utilized for rising gradients. Therefore in hilly areas, laid in valleys, the momentum gained by the train on falling gradient is utilized for rising gradients and at some places, this enables the train to overcome such gradients which are steeper than ruling gradient. Every falling gradients is followed by a rising gradient as far as possible. Such type of gradient, where the advantage of momentum is taken is known as momentum gradients. So on such gradients, no signals are provided, which may stop the train and bring down the momentum to zero.

the full use of locomotive capacity would not be done. In such cases, it is better to concentrate the gradient instead of limiting the load of the train, which will be more economical. At such places, one engine cannot pull the train and extra engine is required to push the train are known as Pusher engines.

4. Station - Yard gradients

on the station - yards gradients are avoided as far as possible due to following reasons :-

1. In station yards, when bogies are standing at gradients, if heavy wind blows, it might start movement of bogies and cause accidents.
2. During the starting time of trains, the locomotive will require extra force to pull the train on gradients.

So gradients are completely avoided ~~on~~ on platforms.

max limit 1 in 400 in station-yard.

In India, 1 in 1000 should be provided for easy draining of station yards.

3. Pusher or Helper gradients.

In mountains, to avoid heavy earth cutting or for reducing length of track, at certain places, steeper gradients than the ruling gradients are provided. If a ruling gradient is provided in the larger length of track, the load carrying capacity of engine shall be reduced, because for the larger portion of the journey

GRADE COMPENSATION ON CURVES

Curves provide extra resistance to the movement of trains. If a curve is situated on a ruling gradient, total resistance would be addition of resistance due to curvature and resistance due to ruling gradient. Inorder to avoid resistances beyond certain limit, the gradients on curves are reduced and such reduction is known as grade compensation on curves. As a result, gradients are compensated to the following extent on curves:

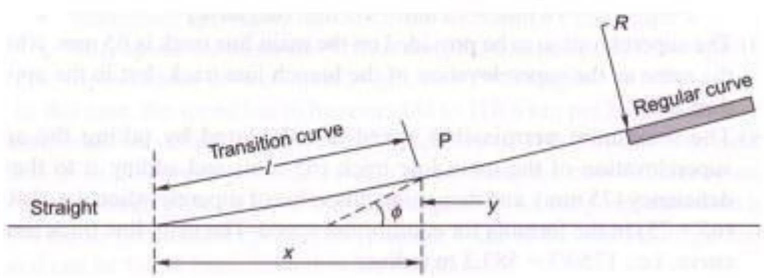
(a) On BG tracks, 0.04 per cent per degree of the curve or 70/R, whichever is minimum

(b) On MG tracks, 0.03 per cent per degree of curve or 52.5/R, whichever is minimum

(c) On NG tracks, 0.02 per cent per degree of curve or 35/R, whichever is minimum where R is the radius of the curve in metres. The gradient of a curved portion of the section should be flatter than the ruling gradient because of the extra resistance offered by the curve.

TRANSITION CURVES

As soon as a train commences motion on a circular curve from a straight line track, it is subjected to a sudden centrifugal force, which not only causes discomfort to the passengers, but also distorts the track alignment and affects the stability of the rolling stock. In order to smoothen the shift from the straight line to the curve, transition curves are provided on either side of the circular curve so that the centrifugal force is built up gradually as the superelevation slowly runs out at a uniform rate.



The following are the objectives of a transition curve:

(a) To decrease the radius of the curvature gradually in a planned way from infinity at the straight line to the specified value of the radius of a circular curve in order to help the vehicle negotiate the curve smoothly.

(b) To provide a gradual increase of the superelevation starting from zero at the straight line to the desired superelevation at the circular curve.

(c) To ensure a gradual increase or decrease of centrifugal forces so as to enable the vehicles to negotiate a curve smoothly.

(d) To create smooth running and imparts comfort to the passengers.

Requirements of an Ideal Transition Curve:

The transition curve should satisfy the following conditions:

(a) It should be tangential to the straight line of the track, i.e., it should start from the straight part of the track with a zero curvature.

(b) It should join the circular curve tangentially, i.e., it should finally have the same curvature as that of the circular curve.

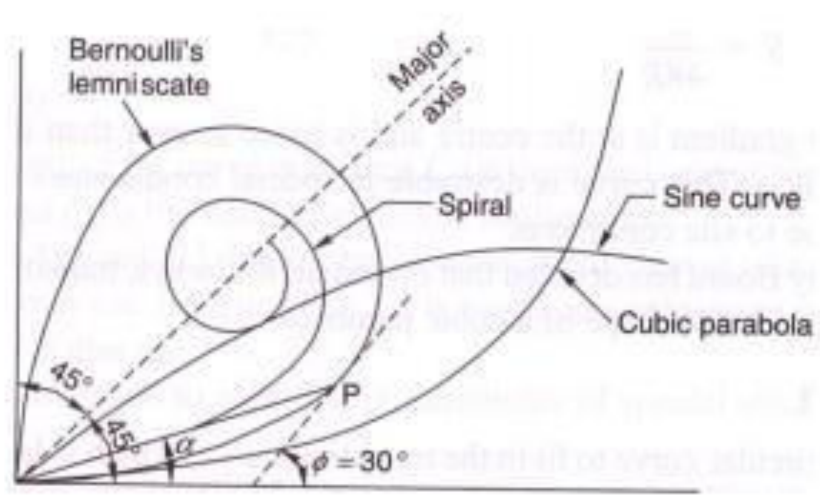
(c) Its curvature should increase at the same rate as the superelevation.

(d) The length of the transition curve should be adequate to attain the final superelevation, which increases gradually at a specified rate.

Types of Transition Curves:

The different types of transition curves are:

a) Euler's spiral
b) Cubical spiral
c) Bernoulli's lemniscate
d) Cubic parabola
e) S-shaped transition curve



Euler's spiral:

This is an ideal transition curve, but is not preferred due to mathematical complications.

Cubical spiral:

This is also a good transition curve, but quite difficult to set on the field.

Bernoulli's lemniscates:

In this curve, the radius decreases as the length increases and this causes the radial acceleration to keep on falling.

Cubic parabola:

Indian Railways mostly uses the cubic parabola for transition curves. The equation of the cubic parabola is:

$$y = \frac{x^3}{6RL}$$

Y= perpendicular off set of transition curve at a distance x from commencement of curve

X= distance of any point on the tangent from the commencement of the curve.

R= Radius of circular curve

L= total length of transition curve.

S-shaped transition curve:

In an S-shaped transition curve, the curvature and superelevation assume the shape of two quadratic parabolas. Instead of a straight line ramp, an S-type parabola ramp is provided with this transition curve.

This curve is desirable in special conditions—when the shift is restricted due to site conditions.

The Railway Board has decided that on Indian Railways, transition curves will normally be laid in the shape of a cubic parabola.

Length of transition curve

The length along the centre line of track from its meetings point with the straight to that of the circular curve is the length of the transition curve. For Indian Railways, this length is foundout by applying following formulas:

1) L = 7.20e

2) L = 0.073 D*V_{max}

3) L = 0.073 e*V_{max}

The greatest of the above three is adopted.

L = length of TC in m

e = actual super elevation in cm

D = cant deficiency for maximum speed in cm

V_{max} = maximum speed in kmph

Shift:

$$S = \frac{L^2}{24R}$$

MODULE – 3

RAILWAY OPERATION AND CONTROL

POINTS AND CROSSING

Introduction

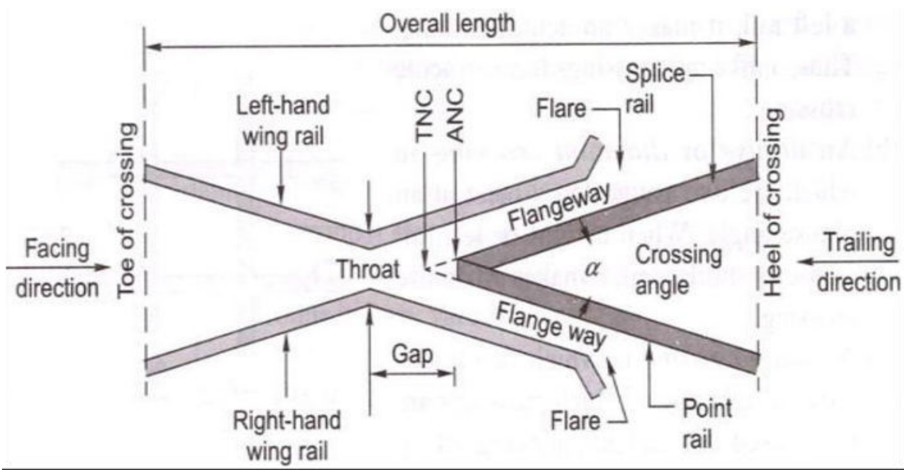
A tongue rail may be either straight or curved. Straight tongue rails have the advantage that they are easily manufactured and can be used for right-hand as well as left-hand turnouts. However, trains get jolted while negotiating with tongue rail turnouts because of the abrupt change in the alignment. Straight rails are normally used for l-in-8.5 and l-in-12 turnouts on Indian Railways. Curved tongue rails are shaped according to the curvature of the turnout ft the toe to the heel of the switch. Curved tongue rails allow for smooth trains, but can only be used for the specific curvature for which they are Curved switches are normally used for 1-in-16 and 1-in-20 IRS (Indian Standard) turnouts on Indian Railways.

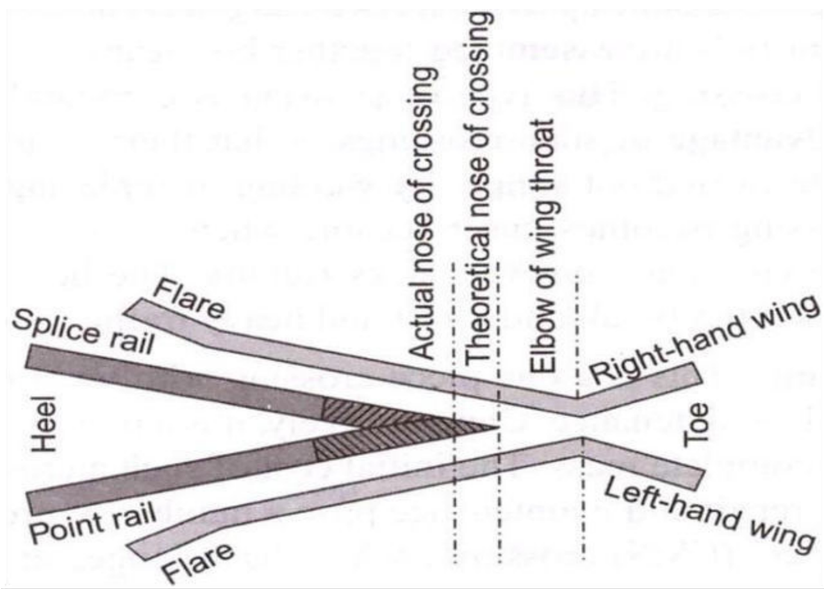
Length of Tongue Rails

The length of a tongue rail from heel to toe varies with the gauge and the switch. The longer the length of the tongue rail, the smoother the entry to the switch because of the smaller angle the switch rail would make with the fixed heel divergence. The longer length of the tongue rail, however, occupies too much layout space in station yards where a number of turnouts have to be laid in space. The length of the tongue rail should be more than the rigid wheel a four-wheeled wagon to preclude the possibility of derailment in case the move from their position when a train is running on the switch.

CROSSING

A crossing or frog is a device introduced at the point where two gauge faces across each other to permit the flanges of a railway vehicle to pass from one tract to another (Fig. below). To achieve this objective, a gap is provided from the throw to the nose of the crossing, over which the flanged wheel glides or jumps. In order to ensure that this flanged wheel negotiates the gap properly and does not strike the nose, the other wheel is guided with the help of check rails. A crossing consists of the following components, shown in Fig. below.

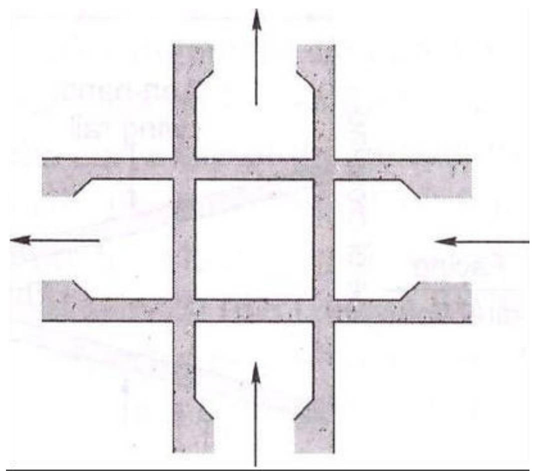




(a) Two rails, point rail and splice rail, which are machined to form a nose. Tic point rail ends at the nose, whereas the splice rail joins it a little behind the nose. Theoretically, the point rail should end in a point and be made as thin as possible, but such a knife edge of the point rail would break off under the movement of traffic. The point rail, therefore, has its fine end slightly cut off form a blunt nose, with a thickness of 6 mm (1/4"). The toe of the blunt nose is called the ***actual nose of crossing*** (ANC) and the theoretical point where the gauge faces from both sides intersect is called the ***theoretical nose of crossing***

(TNC). The 'V rail is planed to a depth of 6 mm (1/4") at the nose and runs out in 89 mm to stop a wheel running in the facing direction from hitting the nose. (b) Two wing rails consisting of a right-hand and a left-hand wing rail that converge to form a throat and diverge again on either side of the nose. Wing rails are flared at the ends to facilitate the entry and exit of the flanged wheel in the gap. (c) A pair of check rails to guide the wheel flanges and provide a path for them, thereby preventing them from moving sideways, which would otherwise may result in the wheel hitting the nose of the crossing as it moves in the facing direction.

(b) **Types of Crossings** A crossing may be of the following types. (a) ***An acute angle crossing*** or 'V crossing (b) ***An obtuse or diamond crossing***. (c) ***A square crossing*** (



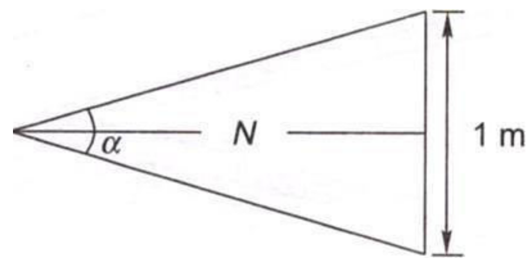
Square crossing

For manufacturing purposes, crossings can also be classified as follows.

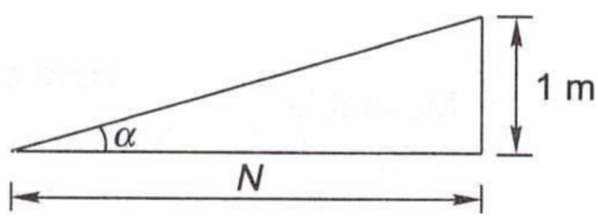
- Built-up crossing
- Cast steel crossing
- Combined rail and cast crossing

NUMBER AND ANGLE OF CROSSING A crossing is designated either by the angle the gauge faces make with each other or, more commonly, by the number of the crossing, represented by N. There are three methods of measuring the number of a crossing, and the value of N also depends upon the method adopted. The methods are illustrated below.

Centre line method: This method is used in Britain and the US. In this method, N is measured along the centre line of the crossing.

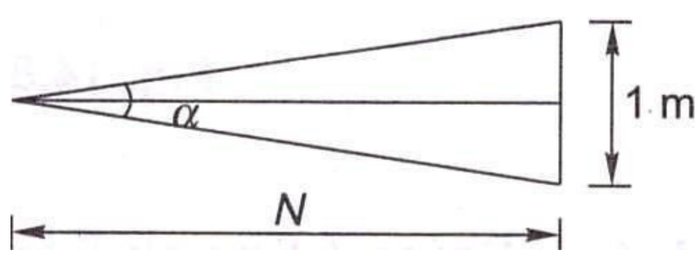


Right angle method: This method is used on Indian Railways. In this method, *N* is measured along the base of a right-angled triangle. This method is also called Coles method. *Cot α/2 – N = N /1/2 or N = 1/2 Cot α/2*



Cot α = N /1 or N = Cot α

Isosceles* triangle *method: In this method, *N* is taken as one of the equal sides of an isosceles triangle.



Sin α/2 = ½ /N or N = 1/2N Cosec α/2 = 2N N = ½ Cosec α/2

The right angle method used on Indian Railways, in which TV is the cotangent of the angle formed by two gauge faces, gives the smallest angle for the same value of *N*. To determine the number of a crossing-on site, the point where the offset gauge face of the turnout track is 1 m is marked. The distance of this point (in metres) from the theoretical nose of crossing gives *N*.

Arrangement by which different routes either parallel or diverging are connected and the means for the train to move from one route to another are known as points and crossing. In the case of railways because the wheels are provided with flanges inside the direction of movement and diversions of vehicle another track are controlled automatically by the wheel flanges rather than the driver as the case of road. The problem of diversion of train from one to another track is called points and crossing.

Turn out

They are the simplest combination of points and crossing. The object of turnout is to provide facility for the safe movement of trains in either direction for both the track.

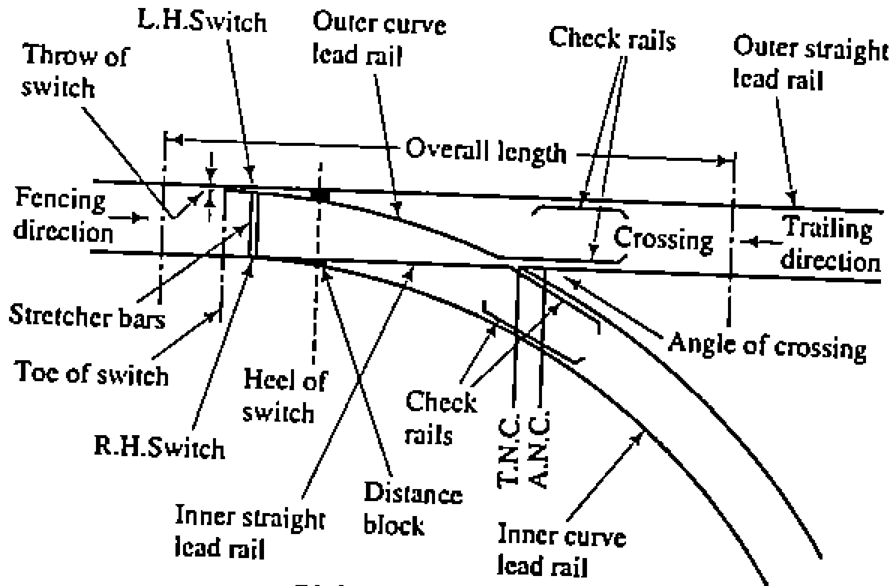
Parts of turnout

1. A pair of points or switches
2. A pair of stock rails
3. A vee crossing
4. Two check rails
5. A lead rails
6. Switch tie plate
7. Studs or stops
8. Bearing plate, single chairs, stretcher bars
9. Operating tools like rods, cranks, lever etc.
10. Locking system including locking box lock bar plunger bar etc.

Principle of turnout

One turnout provide facilities for turning of vehicle from one direction only and not from both the direction of the straight path or route as in the case of road.

Turnout work with the combination of points and crossings i.e. a pair of points or switches four lead rails (2 straight & 2 curved lead rails), 2 check rails and a crossing.



Right hand turnout

Design features of a turnout

C.L → Curve Lead: - distance between theoretical nose of crossing (TNC) and the tangent point T, measured along the length of the track

S.L→ Switch Lead: - Distance between tangent point T and the heel of the switch (SH) measured along the length of the main track.

L → Lead / crossing lead :- distance between theoretical nose of crossing & head of switch measured along the length of the main track.

C.L = S.L + L

β→ Angle of switch :- angle between the gauge

α→ Angle of crossing

d→ heel divergence / clearance

R_0→ radius of outer curve of turn

R → radius of central line of turn

G→ Gauge of track

N → Number of crossing

D→ Distance between theoretical nose of crossing and tangent point of crossing curve

Cot α = N

C.L = 2 GN

$R = R_o - \frac{G}{2}$

$R_0 = 2GN^2 + 1.5\ G$

$S.\ L = \sqrt{2R_0 d}$

L= C.L- S.L

Track Structure

Broad gauge routes have been grouped into 5 broad categories based on speed criteria. Group A, Group B and Group C

Group A → Speed limit upto 160Kmph

B → 130Kmph

C→ Subarban Section

D→ 100Kmph

Meter Guage routes are also

Group ----

,, R_1

,, R_2

,, R_3

,, S

Functions of Track

Broad Gauge

Used for heavier loads and high speed

Narrow Gauge

Used to develop thinly populated area by joining the under developed areas with developed area or urbanised area.

Used in hilly regions will steep gradients and sharp curves. And in plains where high – speed is not required. Light traffic.

Stations and Yards

Station Yards

A yard is defined as the system of tracks laid usually on a level within defined limits for various purposes such as storing of vehicles, making up rails, despatch of vehicle and for other purposes over which movements are not authorised by time table

Classification of station yard

Passenger yards

For the safe movement of passengers and vehicles.

Goods yards

They provide facilities for receiving loading and uploading of goods and movement of goods vehicles.

Locomotive yard

These are used for cleaning repairing, servicing, watering, oiling etc. of locomotives.

Marshalling yards

It is said to be a machine to receive, break up, re form and despatch trains. In other words, a marshalling yard is one where trains and other loads are received, sorted out and new trains formed and despatched onwards to their destinations.

Important functions

1. Reception 2. Sorting 3. Departure

Siding for each functions are also provided. Various sidings are

Reception siding, Sorting siding, Departure siding

Types of Marshalling yards

A marshalling shard can be constructed any of the following type depending upon the ground contours

Flat yards

Here all the sorting work is done by means of locomotive, so there is more power consumption.

Gravitation yard

The tracks are laid at such a gradient that the wagons can move off under the action of gravity.

Hump Yards

Humps or summits or artificial hills are provided and wagons are pushed upon a hump by the engine. The wagons are then allowed to move in to the sidings down the hump under the action of gravity. It is the most economical type since no power is required to move the vagons.

Signalling

Signalling consist of systems devices, signals means by which trains are operated efficiently.

Objects of Signalling

1. To provide facilities for efficient movement of train
2. To ensure safety between two or more trains which cross or approach each other path.
3. To provide facilities for the maximum utility of the track.
4. To provide facilities for safe efficient shunting operations.
5. To guide the trains movement during maintenance and repair of track
6. To safeguard the train at converging and give bidirectional indications at diverging functions.

Types of signals on the basis of characteristics

Operational characteristics

- Detonating Signals
- Hand signal
- Fixed signals

Functional characteristics

- Stop / semaphore type
- Shunting signal
- Coloured light signal

Locational Characteristics

Reception signal

Interlocking

Mechanical relationship established between various levers operating the signals and points through mechanical or electrical agencies such that contrary effects are not at all possible in the working of signal mechanism.

Method of Interlocking

- Tappes and locks system
- Key system
- Route Relay system

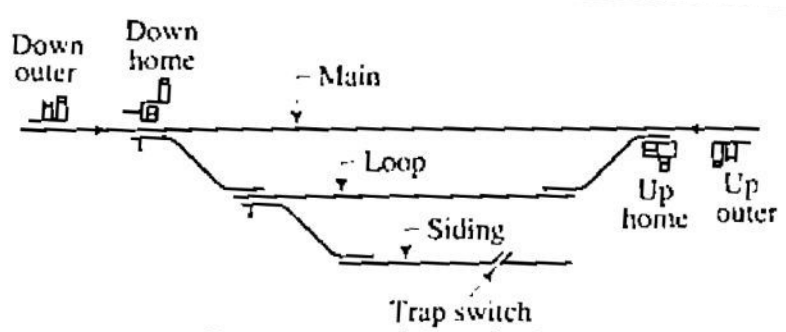


Illustration of interlocking

Track Circuiting

It function to indicate the presence of train on the track showing whether the track is occupied or clear is known as track circuiting.

Principles of track circuiting

The ends of the rails forming the circuits are isolated by using insulated rail joints. The ends of rail of one side are connected to the two terminal of the battery while the other end is connected to an electromagnet called relay, which is in energised condition when there is no vehicle on the track. This normal electrified track is known as primary circuit. The presence of the train short circuit the relay which get de energised breaking the secondary circuit connected with the signal. And ensures that the necessary signal should go to danger indication.

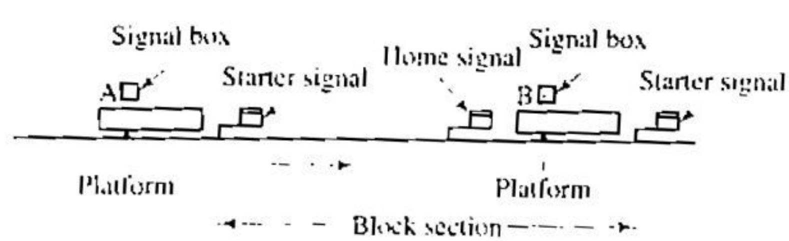
Control of train movements

Basic object of signalling is to control the movement of train to ensure the safety by preventing accidents. For this purposes various methods are found out. Some of which are

1) Absolute Block system / space interval
2) Automatic Block system/ automatic signalling
3) Centralised traffic control system

Absolute Block system

Absolute Block System is extensively use on incline railways. The entire track is divided into block sections separated by block stations. Block station means station provided with block instruments in pairs. These instruments are used to show whether the section ahead is clear or preserved for a train. All block sections are linked in series both telegraphically for operation of block and telephonically for verbal exchange of information. The bock station is under the charge of station master – and the block section is under the joint charge of two adjacent block stations.



Absolute block system

Working procedure

1. The signal man at A draws the attention of signal man at B and ask whether the section is clear or not
2. If the section is clear at B, the signal man at B acknowledges the signals and operates the key and handle in the key box indicating line clear.
3. This information is displayed at both station the signal boxes.
4. The signal man at A lowers his starting signal and allows the train to proceed towards B
5. As soon as the train leave the signal man at sends a signal to the signal man at B indicating train entering the section.

6. The signal man at B acknowledges the signal and places the block indicates as train on line position.
7. The signal man at B operates the home signal at B.
8. The station master at B then sends a message to the next station ahead and procedure is repeated.
9. As soon as the train leaves the stations and has passed the starting signal at B the Station master at B brings his block instrument in the normal position. This gives train out of section signal at A.

Automatic Block System

It is an improvement on absolute block system and avoids the possibility of accident due to the signals are operated by trains itself. An electric current is conveyed through the track and when a train occupies that particular track. The current puts the signal at danger position until the train has gone for ahead. The electricity is transmitted either through overhead lines or through a third rail. The former system is known as catenory system. And the current is obtained through a device called pantograph. In the latter case a metal contact shoe which slides along the charged 3rd rail provided outside the running rails. And electric current is transmitted through is metal shoe.

Advantages

1. The number of signalmen required is less and hence the operating costs are reduced.
2. As human factor is eliminated the value of factor of safety is increased.
3. There is considerable increase in the capacity of the vehicle.

Centralised Traffic control System (CTC System)

A central control room is provided from which the points and signals are controlled. Points and signals are suitably interlocked and an illuminate diagram is provided in the control room to study the movement of the train. The person controlling the panel is known as dispatcher. The dispatcher makes all the arrangement for crossing points and signals. The duty of the driver is nearly to respect the different indications given by the signals.

Advantages

1. Increase the track capacity
2. As the signal cabines are not required great saving in staff.

3. The dispatcher can arrange the train movement in advance and is free to do other works in the office.
4. Points and signals are operated in 2 seconds by means of thumb.
5. The system is capable of detecting the defects in the track.

RAILWAY STATION

It is the selected place on a railway line, where trains halt for one or more of the following purposes.

1. For exchange of passengers
2. For exchange of goods
3. For control of train movements
4. For crossing
5. For overtaking
6. For detaching engines and staff
7. For taking diesel or coal and water for locomotives

Requirements of a Railway Station

1. Public Requirements
2. Traffic requirements
3. Requirements of locomotive department
4. General requirements

Public Requirements: The station should provide all the facilities for the public such as:

- A booking office for tickets.
- Goods and passenger platforms with or without shed.
- Proper arrangement for drinking water.
- Suitable lighting and ventilation.
- Waiting rooms and retiring rooms.
- Sanitary arrangements and waiting rooms.

- Other facilities like public telephone, refreshment room, fax/ telefax facilities, telegraph office, inquiry office etc.
- Provision of refrigerators for cold drinking water in hot weather.
- Microphones to announce the arrival and departure of trains and also for communicating to the public the changes in time schedule, platform number etc.
- Provision of big display boards for train schedule and changes if any.
- Guides from railways dept. to guide illiterate passengers.

Traffic requirements

- Signals
- Recording of movement of trains
- Sufficient no of sidings

Locomotive Requirements

- Proper arrangements for supply of fuel and water
- Arrangements for cleaning, examining, inspecting and maintaining the locomotives

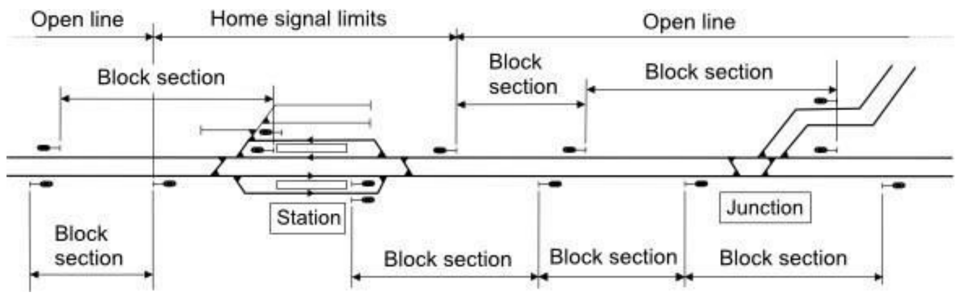
Requirements for development of railways

- Easy and comfortable approach roads to stations
- Installation of clocks, guide map, separate boards for arrival and departure of trains
- Availability of coolies on the platforms
- Escalators, mini theatre , big waiting halls, under ground passages etc.,

RAILWAY STATIONS – CLASSIFICATION

- OPERATIONAL CLASSIFICATION
    - BLOCK STATION
    - NON – BLOCK STATION
    - SPECIAL STATION
- FUNCTIONAL CLASSIFICATION
    - WAYSIDE STATION
    - JUNCTION STATION
    - TERMINAL STATIONS

- **<u>OPERATIONAL CLASSIFICATION</u>**
    - **<u>BLOCK STATION</u>**



- Block sections which are sort of compartments into which the railway line is divided, are established so as to safely space the trains behind each other.
- The 'Block stations' are made at the ends of block section and are equipped with signals which demarcate the limits of block section.
- Here driver has to obtain an authority to proceed
  - **Class A**: Such a station is one where the Line Clear indication for the block may not be given unless the line where the train is to be received is clear at least for up to the starter signal (or, in some cases, for at least 400m ahead of the home signal). These are stations where many trains normally run through without stopping at a high speed, hence the need for the safety margin to prevent accidents in cases of trains overrunning signals. [4/00]
  - **Class B**: Such a station is one where the Line Clear indication may be given before the section of the line within the station has been cleared for reception of a train. Branch lines and routes with lower running speeds fall into this category.
  - **Class C**: This is a station (or *block hut*) marking an end of a block section, with light traffic or where no trains are booked to stop, such as an intermediate block post. (Sometimes these stations exist only in the form of a signal cabin that controls the approach to another station.) Permission to approach may not be given for a train unless the whole of the last preceding train has passed complete at least 400m beyond the home signal and is known to be continuing on its journey.

NON – BLOCK STATION OR CLASS D STATION: This is a station which does not form the boundary of a block section but which does form a stopping place for trains. Trains are stopped by various *ad hoc* arrangements prescribed in view of the local conditions -- the driver may simply know to stop the train there, or it may be flagged down on demand, etc. Also known as a*non-block station* or *flag station*.

SPECIAL STATION:Stations which are not covered under A, B, C & D classes.

FUNCTIONAL CLASSIFICATION

- **WAYSIDE STATION**

- Arrangement is made to cross an up & a down train

- For overtaking of slower trains by the faster trains

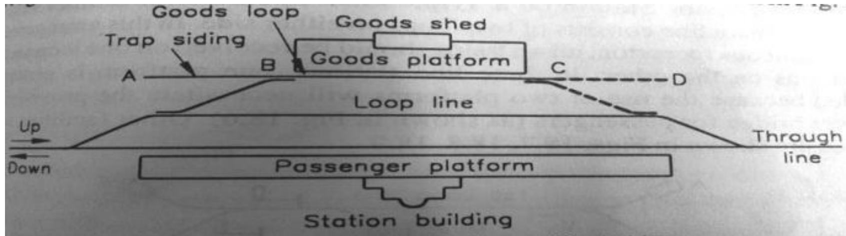


Fig. 18.4. A Wayside Station on Single Line.

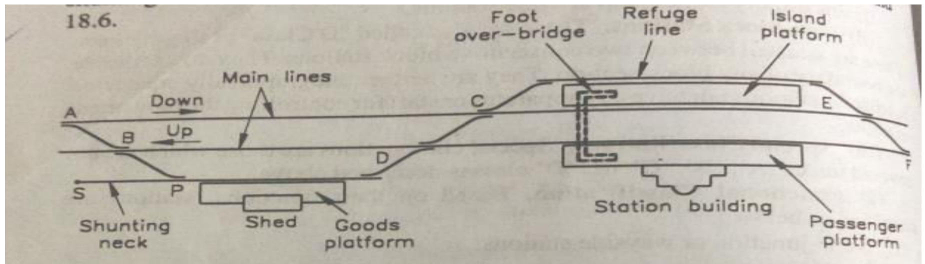


Fig. 18.5. A Wayside Station on a Double Line.

JUNCTION STATION:

- The branch line meets the main line & hence the arrangements are made:
    - to facilitate the interchange of traffic between main & branch lines
    - to clean & repair the vehicles of the trains which terminate at the junction

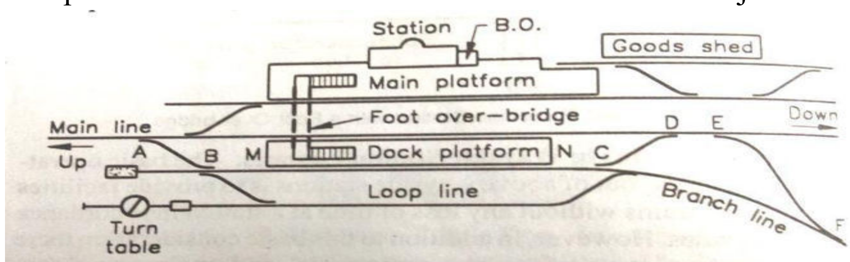


Fig. 18.10 Single Main Line and Single Branch Line Junction.

TERMINAL STATIONS

- The station at which a railway line or one of its branches terminates or ends is known as the terminal station
- Additional arrangements such as facilities to reverse the engines, number of sidings, examination pits etc are to be provided.

comotive touches these buffers.

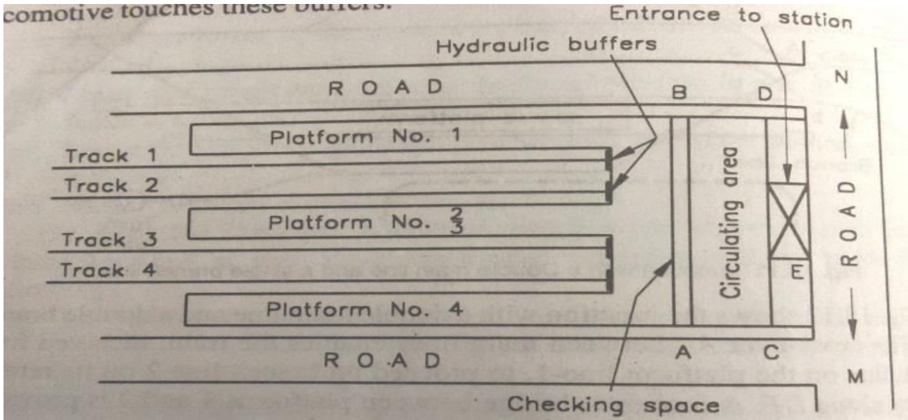


Fig. 18.13 Terminal Station or Junction.