Class – VII Semester / IV Year

Subject –Transportation Engineering

Unit –4 Railway & Airport Engineering

Presented by – Jitesh Kumar Jain (Assistant Professor)

Department of Civil Engineering,

Jaipur Engineering College and Research Centre

Jaipur

VISION

- To become a role model in the field of Civil Engineering for the sustainable development of the society

MISSION

1) To provide outcome base education.
2) To create a learning environment conducive for achieving academic excellence.
3) To prepare civil engineers for the society with high ethical values.

PROGRAMME OUTCOMES (PO)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES

Name of Subject – TRANSPORTATION ENGINEERING

Semester- VII **Code – 7CE4-01**

CO1:-Introduction,modes,development,classification,planning & alignment of highway in India.

CO2:-Design of highway & desirable properties, testing of material as per IRC code.

CO 3:-Method of highway construction, Equipment & design of flexible & rigid pavements as per IRC.

CO4:-Introduction of Railway,Waterways,Airways,Engineering

INTRODUCTION

- "Transportation is regarded as an index of Economic, Social and commercial progress of the country".
- Modes of Transport
  - Land transport
  - Water transport
  - Air transport

- Two major means of land transport are Roads and railways.

ADVANTAGES OF RAILWAYS

- **Political Advantages**
  - Railway have joined people of different castes, religions customs and traditions.
  - With adequate network of railway central administration has become easy and effective
  - Role of railway during emergencies in mobilising troops and war equipment has been very significant.
  - Railway have helped in mass migration of people.
- **Social Advantages**
  - Feeling of isolation has been removed from the inhabitants of Indian villages.
  - The social outlook of the masses has been broadened through railway journeys.
  - Railway has made it easier to reach religious importance
  - Provide safe and convenient mode of transport for the country

- **Economic advantages**
  - Mobility of people has increased.
  - Transport food and clothes during famines.
  - Transport raw material to the industries
  - Provide employment to millions of people.
  - Land values increased due to industrial development.
  - Price stabilization is possible.

- **Techno-economic advantages**
- Cost saving in transportation of long haul bulk traffic.
- Energy efficient (1/7 fuel used as compared to road sector)
- Environment friendliness
- Higher Safety (fatal accidents 1/10 of road sector in India)

DEVELOPMENT OF INDIAN RAILWAY (IR)

- In 19 century before the introduction of railways, India was a country with extremely poor means of communications.
- In1844 the first proposals for the construction of railway on India was submitted to East India Company
- In 1853 first railway line between Bombay to Thana was opened.
- In 1905 Railway Board was established with one president and two members.
- In 1939 total route kilo meter of India was 65,850 km.

TYPES OF GAUGES PREVALENT IN INDIA

- The different gauges prevalent in ***India*** are of the following these types :-

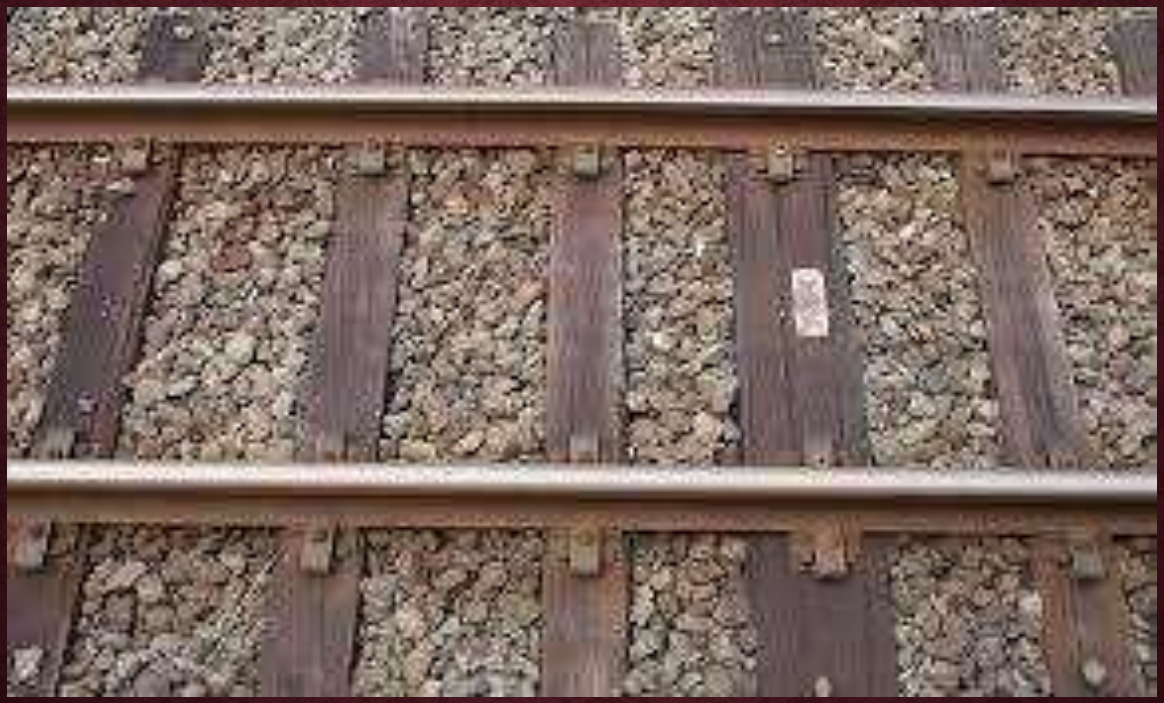
1.Broad gauge (1676),

2.Meter gauge (1000),

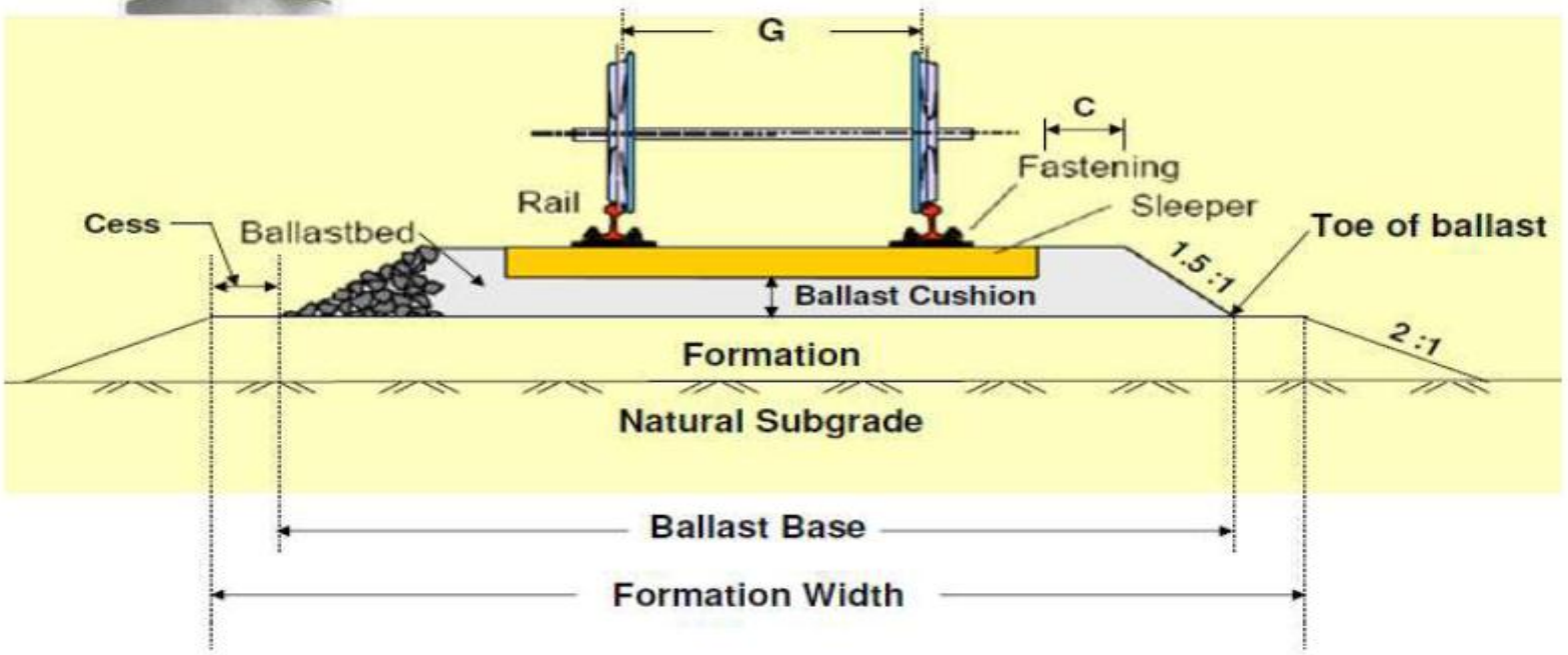
3.Narrow gauge (762 mm & 610 mm).

- *In India, efforts are being made to convert all N.G. and M.G. lines to B.G. lines on important sections as and when funds are available.*

- *Permanent way*: The combination of ***rails,*** fitted on ***sleepers*** with the help of ***fixtures*** and ***fastenings*** and resting on ***ballast*** and ***subgrade*** is called the railway track or permanent way.



TRACK STRUCTURE



TRACK CROSS SECTION

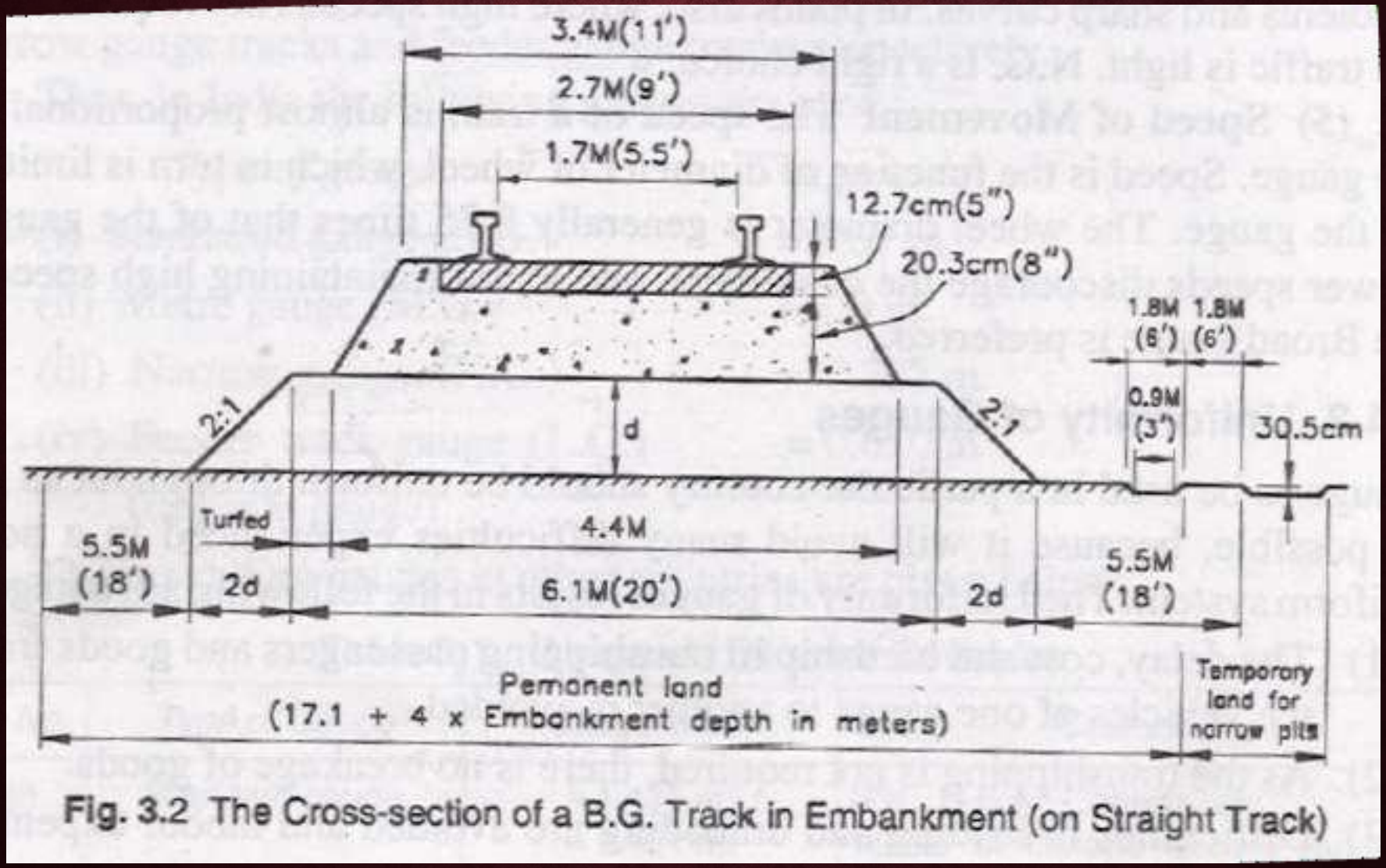
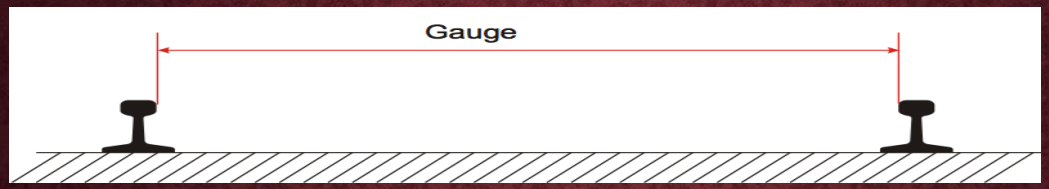


Fig. 3.2 The Cross-section of a B.G. Track in Embankment (on Straight Track)

TRACK COMPONENTS

- Gauge: defined as the minimum distance between two rails. Indian Railway follows this practice.

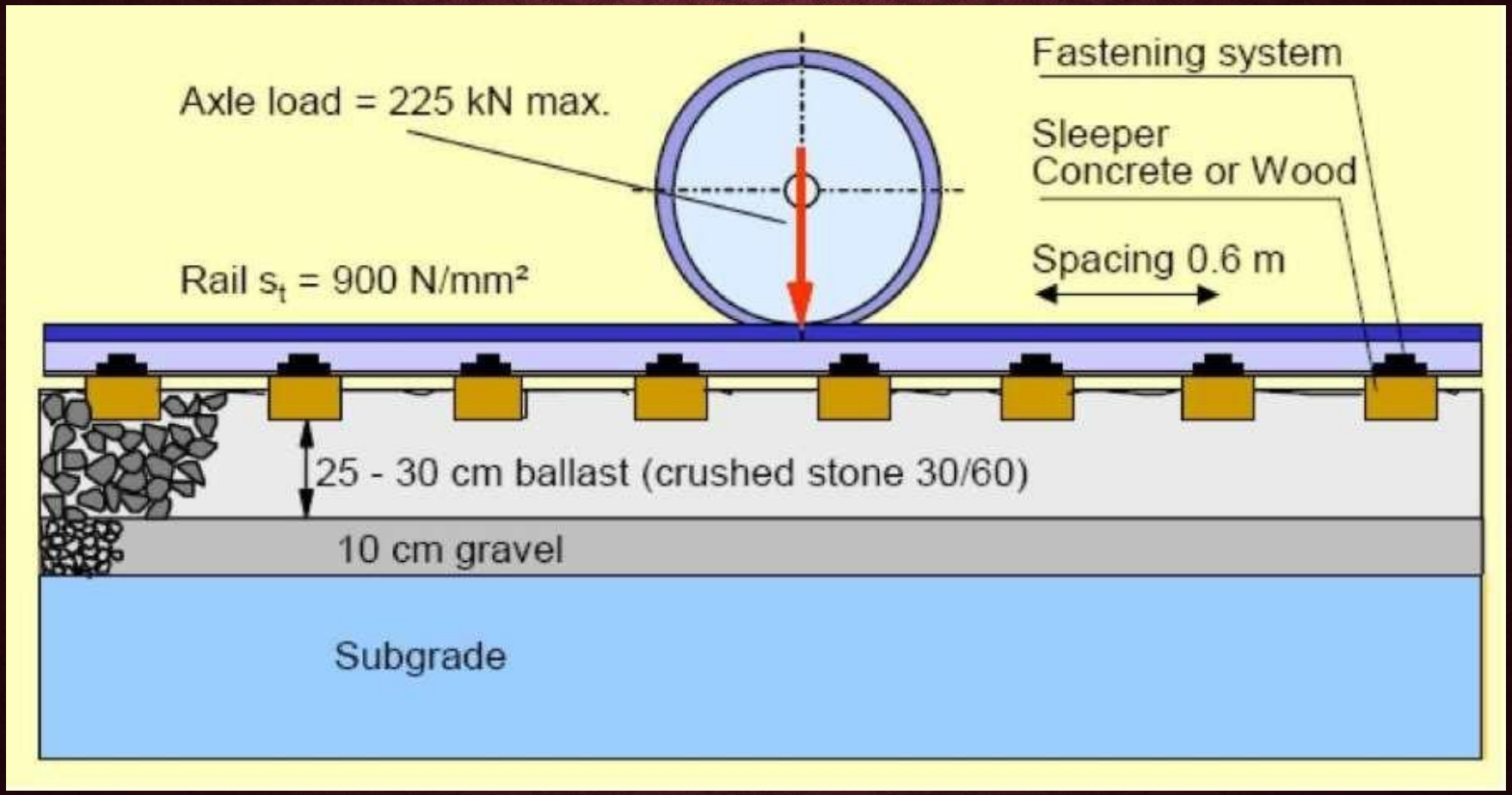


- Rails act as girders to transmit the wheel load to the sleepers.
- Rails are joined in series by welding a few of them (5 of them) and the welded lengths are joined by fish plates and bolts.
- Rails are fixed to sleepers by different types of fixtures and fastenings (chairs, bearing plates, fish plates, fish bolts, spikes etc.).
- Sleepers hold the rails in proper position with respect to their proper tilt, gauge and level and transmit the load from rails to the ballast. These sleepers are suitably spaced, packed and boxed (the process of filling the ballast around the sleepers) with ballast. The typical length of a BG sleeper is 2.7 m.

- Ballast is a high quality crushed stone with desired specifications placed directly below the sleeper.
- Ballast distributes the load over the formation and holds the sleepers in position and also functions as drainage layer.
- Formation is the compacted and prepared subgrade which is the part of embankment or cutting
- Natural subgrade is the soil in the natural ground on which the track rests.
- Ballast cushion**:** The depth of ballast below the bottom of the sleeper, normally measured under rail seat is termed as ballast cushion.

- **Ballast shoulder:** Ballast provided beyond the
- sleeper edge is termed as ballast shoulder (shown as *C* in Fig., typically 0.35 m in a BG track)
- **Ballast Base:** It is the bottom width of ballast- bed (typically 4.4 m in a BG track).
- **Formation width:** It is the top width of embankment or bottom width of cutting (Typically 6.1 m in a BG track)
- **Cess width:** Width of formation beyond the toe of ballast is termed as cess width.

CONVENTIONAL TRACK STRUCTURE



REQUIREMENTS OF AN IDEAL PERMANENT WAY

- *The following are the principal requirements of an ideal permanent way or of a good railway track :-*

i. The gauge of the permanent way should be correct and uniform.

ii. The rail should be in proper level in straight portion. Proper amount of *super elevation* should be provided to the outer rail above the inner rail on curved portion of the track.

iii. The permanent way should be sufficiently strong against lateral forces.

iv. The curves, provided in the track, should be properly designed.

v. An even and uniform gradient should be provided through out the length of the track.

vi. The *tractive resistance* of the track should be minimum.

vii.The design of the permanent way should be such that the load of the train is uniformly distributed on both the rails so as to prevent unequal settlement of the track.

viii.All the components parts such as rails, sleepers, ballast, fixtures and fastenings, etc. should satisfy the design requirements

ix.All the points and crossings, laid in the permanent way, should be properly designed and carefully constructed.

x.It should be provided with proper drainage facilities so as to drain off the rain water quickly away from the track.

xi.It should be provided with safe and strong bridges coming in the alignment of the track.

xii.It should be so constructed that repairs and renewals of any of its portion can be carried out without any difficulty.

SELECTION OF GUAGES

1.Cost of construction

- There is marginal increase in the cost of earthwork, rails, sleepers, ballast, and other track items with gauge.
- The cost of station buildings, platforms, signals, bridges, tunnels and culverts etc., is same more or less for all gauges.
- There is little proportional in the acquisition of land.
- The cost of rolling stock is independent of the guage used for same volume of traffic.

2.Volume and nature of traffic.

- For heavier loads and high speed, the wider guage are required because subsequently the operating cost per tonne-km is less for higher carrying capacity.

3.Speed of movement

- Speed is a function of dia. of wheel, which in turn limited by the guage. (wheel diameter =0.75 x Gauge).

4.**Development of areas**

- Narrow guages can be used for thinly populated area by joining under developed area with developed or urbanised area.

5.Physical features of the country

- Use of narrow guage is warranted in hilly regions where broad and meter guage are not possible due steep gradients and sharp curves.

RAILS

- The rails on the track can be considered as steel girders for the purpose carrying axle loads. Flat footed rails are mostly used in Indian railways.
- Functions of Rails
  - Provide hard, smooth and unchanging surface for the passage of heavy moving loads with minimum friction steel rails and steel wheels.
  - The rail material should be such that it gives minimum wear to avoid replacement and failure.
  - Rail transmit loads to the sleepers and
- consequently reduce pressure on ballast and formation below.
- Composition of rail steel
- **For ordinary rails**
- Carbon (C) - 0.55 to 0.68 percent Manganese (Mn) - 0.65 to 0.9 percent Silicon (Si) - 0.05 to 0.3 percent Sulphur (S) – 0.05 percent or below
- Phosphorus (P) – 0.06 percent or below

- **For rails at points and crossings**
- Carbon (C) - 0.5 to 0.6 percent Manganese (Mn) - 0.95 to 1.25 percent Silicon (Si) - 0.05 to 0.2 percent Sulphur (S) – 0.06 percent or below
- Phosphorus (P) – 0.06 percent or below

REQUIREMENTS OF RAILS

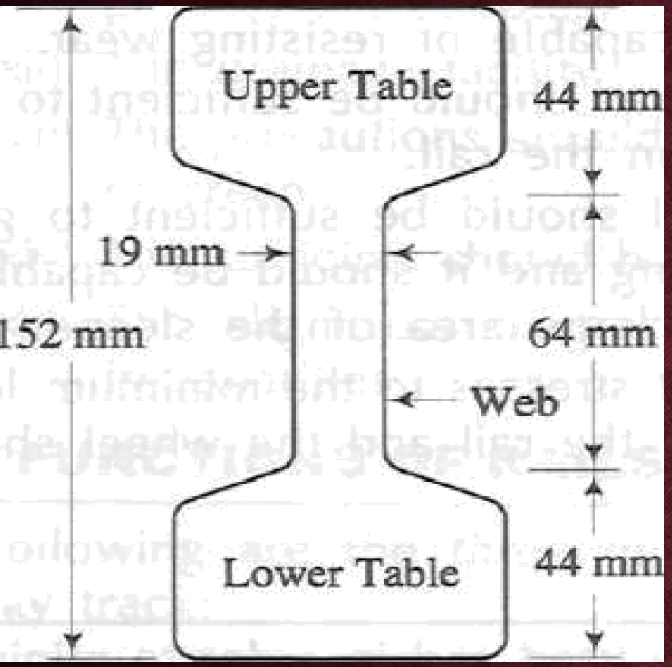
- They should be of proper composition of steel and should be manufactured by open hearth or duplex process.
- The vertical stiffness should be high enough to transmit the load to several sleepers underneath.
- Rails should be capable of withstanding lateral forces. Large width of head and foot endows the rail with high lateral stiffness.
- The head should be sufficiently deep to allow for an adequate margin of vertical wear.
- Web of the rail should be sufficiently thick to bear the load coming on it and should provide adequate flexural rigidity in horizontal plane.

- Foot should be wide enough so that rails are stable so that rails are stable against overturning especially on curves.
- Bottom of the head of rail and top of the foot should be so shaped as to enable the fish plate to transmit the vertical load efficiently from head to the foot at rail joints.
- The centre of gravity of the rail section must lie approximately at mid height so that the maximum tensile and compressive stresses are equal.
- The tensile strength of the rail piece should not be less than 72 kg/mm^2.

TYPES OF RAIL SECTIONS

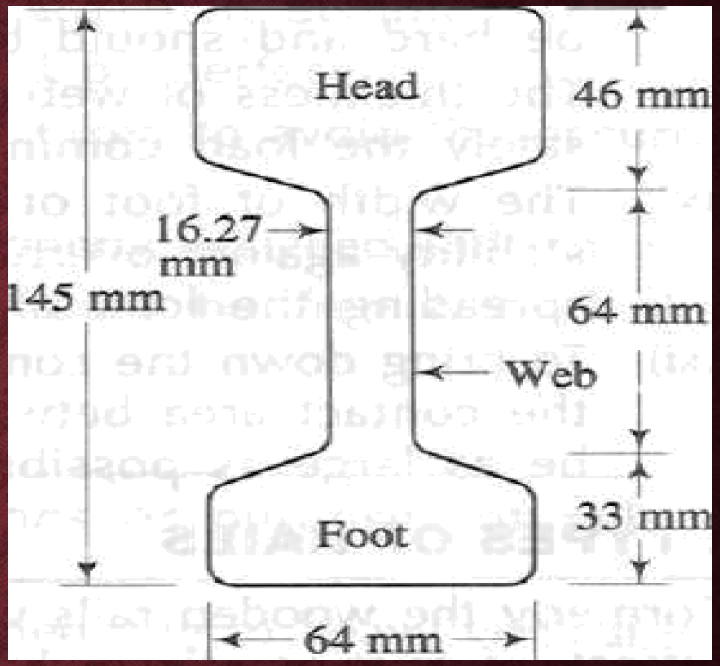
- Double headed rails(D.H Rails)
- Bull headed rails(B.H rails)
- Flat footed rails(F.F rails)

- 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 rail can be inverted or reused. But the experience shows that such indentation are formed in lower table due to which smooth running over that surface at the top was impossible.



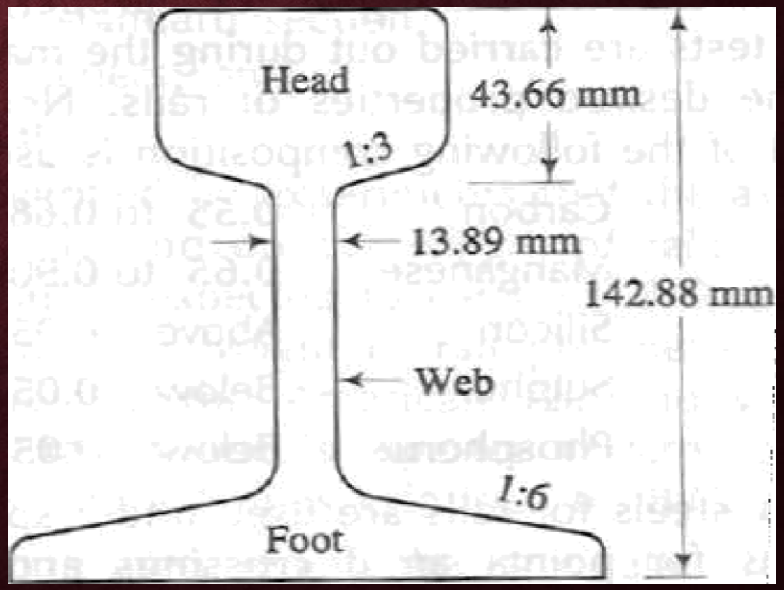
Double headed rails(D.H Rails)

Bull headed rails(D.H Rails)



Flat footed rails(F.F rails)

Rails)



- The next evolution was that of a bull headed rail in
  - which the head is made little thicker and stronger than the lower part, by adding more metal to it, so that even after wear, it can withstand stresses.
  - In designing flat footed rails it was initially thought that flat footed rail can be fixed to the sleepers directly and would eliminate the need for chairs and keys required for the bull headed rails. However it was observed that heavy train load cause the foot of the foot of rail to sink into wooden sleeper, to remedy this steel plates are used between the sleeper and the rails at joint and other important places.

Table 6.3 Comparison of Rail Types

S. No.	Point of Comparison	*Flat-footed Rails*	*Bull-headed Rails and Double-headed Rails*
1.	Strength and Stiffness	These have more strength and stiffness for the same weight, both laterally and vertically.	These have less strength and stiffness.
2.	Laying and Relaying	Fitting of these rails is simpler and so can be easily laid and relaid. No chairs are required.	The fitting of these rails is difficult and time-consuming as they are supported on chairs.
3.	Arrangements at points, crossings and at sharp curves	The arrangements are simpler and easy.	The arrangements are complicated and difficult.
4.	Alignment and stability of track	In this, impact of Rolling wheels affects the fittings and the loosening of fittings disturbs the alignment and gives less stability	These rails when fitted on chairs, provide a more solid, smooth track and better stable alignment.
5.	Initial cost	These rails require lesser and cheaper fastenings, so the initial cost is less.	These require more and costly fastenings and hence initial cost is more.
6.	Rigidity	These rails can be used, without bearing plates on sleepers as these rails are strong to withstand vertical loads. Hence they are more rigid.	These rails without chairs cannot be used on inferior type of sleepers, being less strong against vertical loads. Hence they are less rigid.
7.	Inspection	Daily inspection is not necessary as no special risk is involved.	In case of B.H. or D.H. rails, daily inspection of wooden keys is necessary.
8.	Replacement of rails	In F.F. rails, the dog spikes have to be taken out in addition to fish bolts and fish plates to change the rail. So replacement is difficult.	These rails can be changed easily by driving out the keys and taking out fish bolts and fish plates, without disturbing sleepers.
9.	Maintenance cost	The maintenance cost is less.	It requires heavy maintenance cost.
10.	Suitability	These are more suitable due to better stability, economy, strength and stiffness.	These are more suitable when lateral loads are more important rather than vertical loads.

STANDARD RAIL SECTIONS & RAIL LENGTH

Table 6.1. Standard Rail Sections Gauge-wise

Gauge	Rail Section	Type of Section	Rail Length	Rail Section kg/m
1. Broad Gauge (B.G.)	60 kg/m 52 kg/m 90 lbs/yd	60 MR (UJC) 52 MR (IRS) 90 R (RBS)	13 metre (42 ft old)	60.34 60 MR 51.89 52 MR 44.61 45 MR
2. Metre Gauge (M.G.)	90 lbs/yd 75 lbs/yd 60 lbs/yd	90 R (RBS) 75 R (RBS) 60 R (RBS)	12 metre (39 ft old)	44.61 45 MR 37.13 37 MR 29.76 30 MR
3. Narrow Gauge (N.G.)	50 lbs/yd	50 R (RBS)	12 metre (39 ft old)	24.80 25 MR

Notes : Except for 60 MR and 52 MR all rails are designated in FPS units but their dimensions in weights are :

—MR (IRS) Metric Rail kg/m as per Indian Railway standards.

—R (RBS) British Rail lbs/yd as per revised British standards (RBS)

DETAILS OF STANDARD RAIL SECTIONS

- 90 R rail section was considered adequate only for annual traffic of about 10 gross million Tonne (GMT) speeds upto 100 kmph and service life upto 20 to 25 yrs.
- 52 MR (i.e.52 kg/m) rails are suitable for use of speed of 130 kmph and traffic density of 20 to 25 GMT.
- 60 MR (i.e. 60 kg/m) rails are suitable for use upto a speed of 160 kmph and traffic density of about 35 GMT.

Table 6.2 Details of Standard Rail Sections in use on Indian Railways

S. No.	Type of Rail Section	Wt/Metre (kg)	Area of Section (Sq mm)	Dimensions of Rail Section (mm)					
				A	B	C	D	E	F
1.	50 R*	24.80	3168	104.8	100.0	52.4	9.9	32.9	15.1
2.	60 R*	29.76	3800	114.3	109.5	57.2	11.1	35.7	16.7
3.	75 R*	37.13	4737	128.6	122.2	61.9	13.1	39.7	18.7
4.	90 R*	44.61	5795	142.9	136.5	66.7	13.9	43.7	20.6
5.	52 kg** (IRS)	51.89	6615	156	136	67	15.5	51	29
6.	60 kg** (UIC)	60.34	7686	172	150	74.3	16.5	51	31.5

*As per Revised British standards '*R*' wt lbs/sq yd (RBS)
**Weight as per Metric Standards

- **Hogged rails**: due to battering action of wheels over the end of rails, the rail get bent down and deflected at the ends, this hogging is due to loose packing under the joint and/or loose fish plate. Can be removed by
- Cropping, replacing, welding and dehogging.
- **Kinks in rails:** when the ends of adjoining rails move slightly out of position , “shoulders” or “kinks” are formed. Kinks formed due to loose packing at joints, defects in guage, and alignment, defects in cross level at joints, uneven wear of rail head, where kinks are formed at joints.
- Buckling of rails: buckling means track has gone out of its original position or alignment due to prevention of expansion of rails in hot weather on account of temperature variations. Causes are following

i. When expansion gap is not sufficient

ii. The fish plate are bolted so tight that no slip is allowed.

iii. Due to presence of longer welded rail on weak tracks.

WEAR ON RAILS

- Wear is one of the prominent defects of rails. Due to heavy loads concentrated stresses exceeds the elastic limit resulting in metal flow; on the gap or joints the ends are battered and at the curves the occurrence of skidding, slipping and striking of wheel flanges with rails results in wear and tear on rails.

- **Classification of wear**

i. On the basis of location

ii. On sharp curves

iii. On gradients

iv. On approach to stations

v. In coastal area etc.

- **On the basis position of wear**

i. On the top of rail

ii. At the end of rail

iii. on the sides of the head

• Methods to reduce wear

- When wear exceeds the permissible limit (5 % of the total weight section) the rail must be replaced.
- Use of special alloy steel at the location where wear is more.
- Reduction in number of joints by welding
- Regular tightening of fish bolts and packing of ballasts.
- Welding and dehogging of battered ends in time also the wear.
- Maintenance of correct gauge will reduce the
- side wear in particular.
- Lubricating of the gauge face of outer rail on curve, will also reduce the wear.
- Interchanging of inner and outer rails and changing face at curve will reduce the wear.
- Application of heavy mineral oil, in case of corrosion of rail metal under adverse atmospheric conditions, reduce the wear of rail.

• Creep of rails

- Longitudinal movement of rail with respect to sleepers in a track is called creep.
  - **Indication of creep**
- Closing of expansion spaces at joints
- Marks on flanges and web of rails made by spike head, by scraping or scratching at rail slide.

• Theories of creep

- Wave action or wave theory:
- Wave motion is set up by moving loads of wheels.
- The vertical reverse curve ABC is formed in the rail ahead of wheels, resulting from the rail deflection under the load.

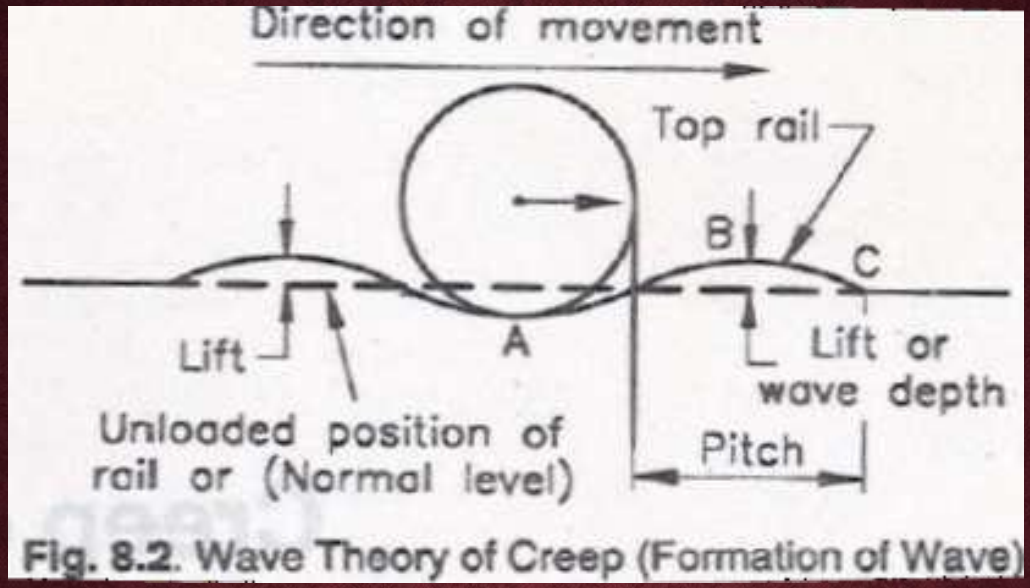


Fig. 8.2. Wave Theory of Creep (Formation of Wave)

2.Drag (or) Dragging theory:

- Backward thrust on driving wheels of locomotiveof train push the rail off track backward.
- Mean while other wheel of locomotive and vehicles push
- the rail in the direction of travel.
- Since drag effect is more as explained in Wave Action Theory resultant creep of rails in forward direction.
- 3.. Percussion Theory:
- This theory states that the creep is due to impact of wheels at the rail end ahead at joints. Hence as and when wheel leave the trailing rail and strike the facing rail end at each joint it pushes the rail in forward direction resulting in creep.

4.Starting, accelerating, Slowing down (or)

- stopping of a train:
- Backward thrust of the engine driving wheels push the rails backward when a train is starting and accelerating.
- When slowing down or stop the vehicle braking forces are push the rail forward.

5.Unbalanced Traffic:

- Single line:
- Heavy equal loads pass in both direction, the creep is balanced. If not creep takes place in the heavy load direction.
- Double line:
- Since loads are in unidirectional creep occurs in both directions.

Factors effecting the magnitude & direction of creep.

- Alignment of track: Creep is more on curves than on tangent tracks.
- Grade of track: More in case of steep curves, particularly while train moving downward with heavy loads.
- Type of rails: older rail have more tendency than new one.
- Direction of heaviest traffic: In heavier load moving direction occurs more creep.

- **Effects of Creep**

- Most serious effect of creep is being buckling of track.
- Common effects of creep:
- Sleepers move out of square and out of position, affects the gauge and alignment of track. As sleepers move surface is disturbed results uncomfortable riding.
- When joints are opened out beyond the permissible stress in bolts and fish plates tendency to occurrence of failure in them.
- Rails ends also battered due to occurrence of excessive gaps at joints. While at other places , joints are jammed and prevent required expansion due to thermal stresses.
- Points and crossings get distorted, its too difficult to set them to correct gauge and alignment. Movement of switches is made difficult and interlocking is thrown out of gear.

•Its difficult to fix the removed rail at proper

•position during repair works since the time gap becomes too short or too long due to creep.

•Smashing of fish plates, bolts, bending of bars, kinks at joints of rails and forging of ballast ahead, common effects of creep.

•If creep is not prevented in time it will results derailment.

- **Remedies of creep:**

1. Pulling back the rails:

✓ pull back the rail to its original position. By means of crow bars and hooks provided through the fish bolts wholes of rails

✓ By considering the position of joints relative to sleepers and both rails should be in respective position.

1. Provision of anchors :
   - ✓ By use of anchors and sufficient crib ballast.
   - ✓ For creep 7.5 cm-15 cm 4 anchors per rail
   - ✓ For creep 22.5 to 25 cm 6 anchors.
2. Use of steel sleepers:

- ✓ Sleepers should be made up of good material with proper fitting.Sleepers should provide good grip with ballast to resist the movement of sleepers. Increase in no. of sleepers.

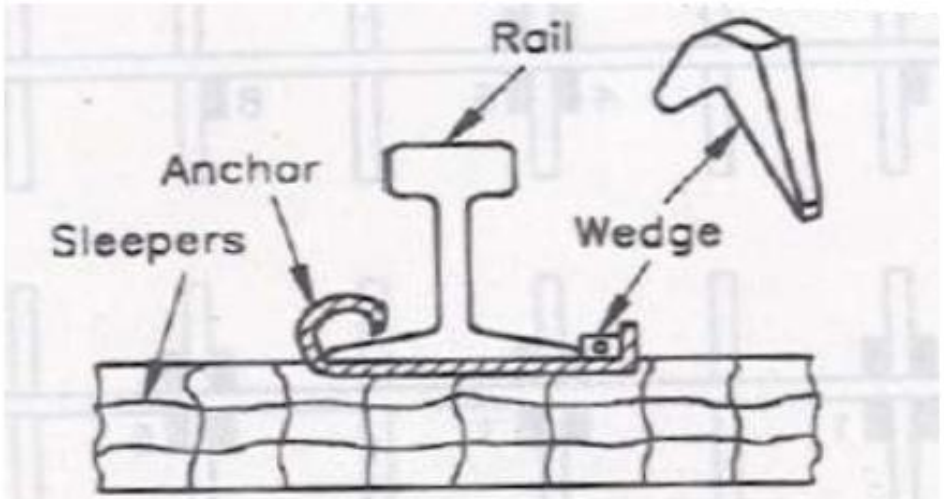


Fig. 8.5. Anchor placed by Wedging Action

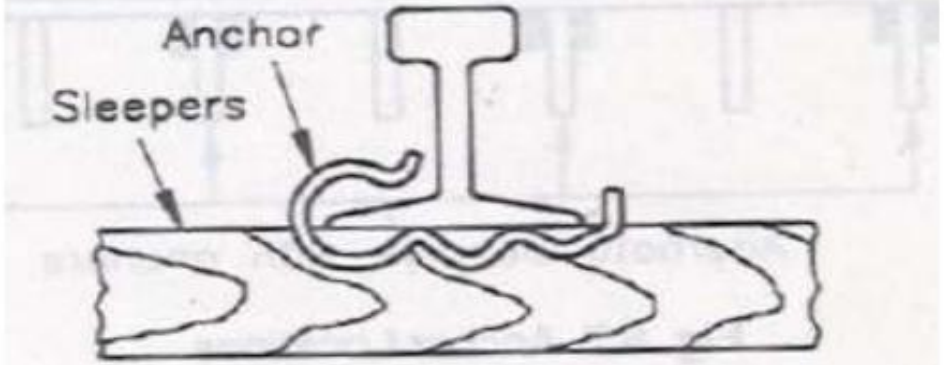
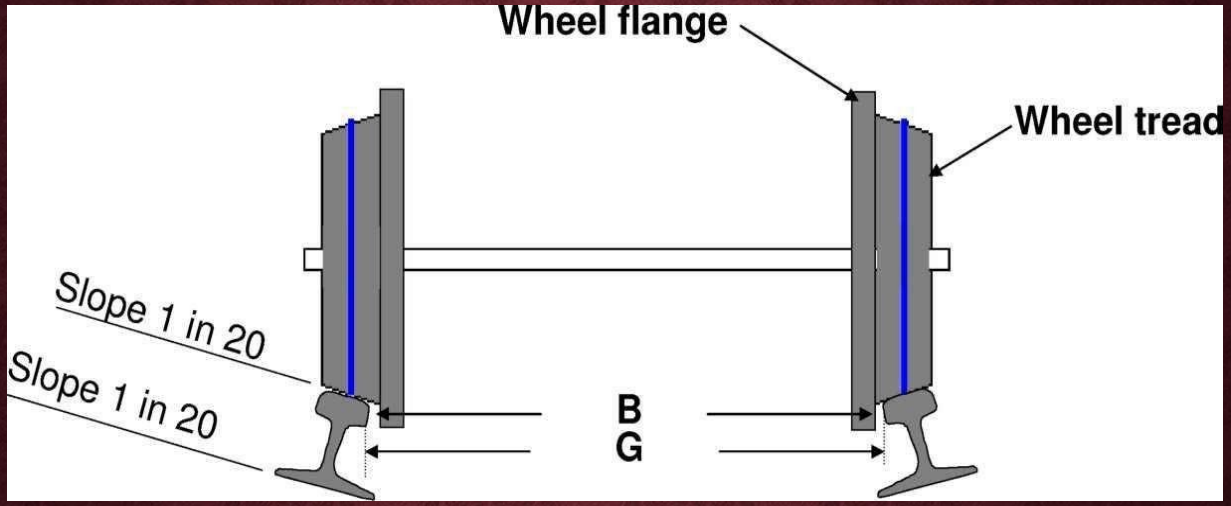


Fig. 8.6. Anchor placed by a Spring Grip

Anchor placed by a Spring Grip

• Coning of Wheels



The wheels of locomotive are not flat but sloped or coned at a slope of 1 in 20.

The distance between inside edges of wheel flanges (B) is generally kept less than the gauge (G). This results in a gap of 1 cm between flange and running face of rail.

- **Theory of coning**

- Advantages of coning:

✓ Reduce the wear and tear of wheel flanges and rails.

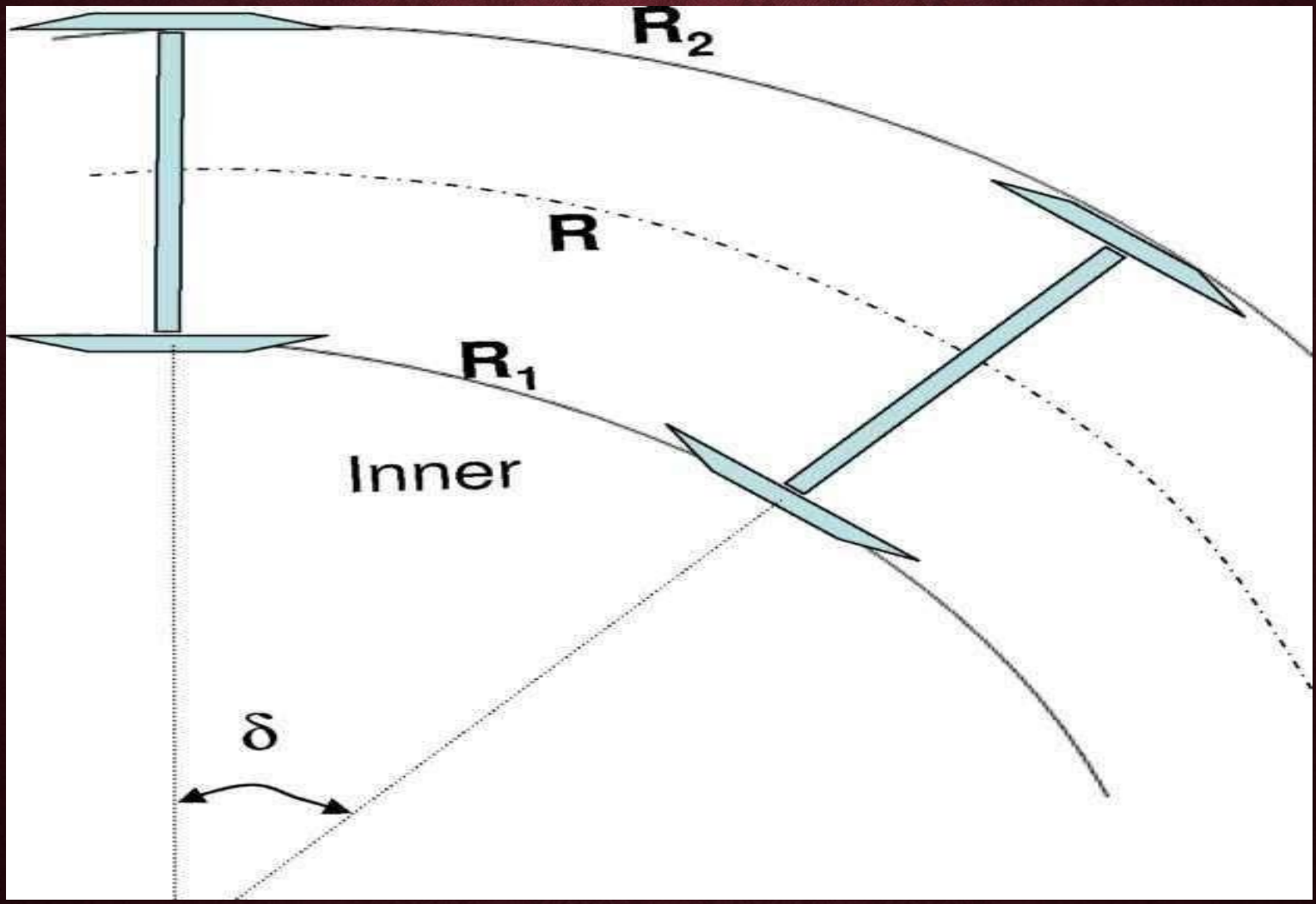
✓ To provide possibility of lateral movement of the axle with its wheels.

✓ To prevent the slipping of

wheels. Theory of coning:

✓ On level track, as soon as the axle moves towards one rail, the dia of the wheel tread over the rail increases, while it decreases over the other rail. This prevents the further movement and axle get back to its original position.

✓ Due to rigidity of the wheel base either the wheel must slip by an amount equal to the difference of length or the axle move slightly outwards to provide a tread of longer
diameter
over the outer rail and smaller diameter over the inner rail.


R2
R
R1
Inner
δ

- If the tread dia. on both the rails is same then amount of slip is:
- Slip=$\theta (R_2-R_1)$
- Where, outer radius, $R_2=R+(G/2)$
- $R_1= R-(G/2)$
- G=Gauge
- θ=angle at centre in radians. Slip= $\theta \times G$
  - G=1.676 meters for B.G Slip= $(2\pi\theta^{\circ}/360)\times 1.676$
- θ°=angle at centre (degree)

- Therefore, Slip = 0.029 m per degree of central angle

- **SLEEPERS**
  - Sleepers: these are members laid transverse to the rails on which rails are supported and fixed to transfer the loads from rail to ballast and subgrade below.
  - Functions of sleepers:

- To hold the rails to correct gauge.
- To act an elastic medium between the ballast and rail to absorb the blows and vibrations due to moving loads.
- To distribute load from the rail to the index area of ballast or to the girders in case of bridges.
- To support rails - at proper level in straight tracks

- - at proper super elevation on curves

- Sleepers also provide longitudinal and lateral
  - stability of the permanent track on the whole.
- Requirements of sleepers: an ideal sleeper should possess the following characteristics.
- Sleeper should be economical i.e, minimum initial and maintenance cost.
- Fitting of the sleepers should be easily adjustable during maintenance operations. Such as
  - ✓ Lifting
  - ✓ Packing,
  - ✓ Removal and replacements.

✓ The weight of the sleeper should not be too heavy or excessively light i.e. with moderate weight they should be for ease of handling.

✓ Design of sleepers should be such a way that the gauge and alignment of track and levels of the rails can easily adjusted and maintained.

✓ The bearing area of sleepers below the rail seat and over the ballast should be enough to resist the crushing due to rail seat and crushing of ballast under sleepers.

✓ Design and spacing such a way to facilitate easy removal and replacement of ballast.

- Sleepers should be capable of resisting shocks
- and vibrations due to passage of heavy loads of high speed trains.
- Sleepers design should be such a way they are not damaged during packing process.
- Design should be strong enough so that they are not pushed out easily due to the moving trains especially in case of steel sleepers with rounded ends.
- An ideal sleeper should be anti-sabotage and anti-theft qualities.

- Classification of sleepers.

1. Wooden sleepers:

✓ Wooden sleepers regarded to be best as they are fulfill all the requirements of ideal sleeper.

✓ Life of timber sleepers depends on their ability to resist wear, decay, attack by vermin, and quality of timber.

✓ Easily available (Sal, teak, chir and deodar).

✓ Fittings to the wooden sleepers are few and simple in design.

✓ Resist shock and vibrations.

✓ But it is difficult to maintain gauge in case of wooden sleepers.

✓ Service life is minimum (12 to 15 years) and maintenance cost is also high as compared to other sleepers.

- Composite sleeper index (C.S.I):

- It is an index to determine the suitability of timber for use as a sleeper.
- This is measure the mechanical strength of timber, derived from its composite properties of strength and hardness.

- C.S.I = (S+10H)/20

- min value of CSI are 783,1352and 1455 for track, crossing and bridge sleeper respectively.
- S= strength index both for green and dry timber at 12% of moisture content.
- H=hardness index both for green and dry timber at 12% of moisture content.

- Treatment of wooden sleepers:

✓ To improve the life of timber up to 30 to 50%.

✓ Timber has minute cells filled with juices, therefore by replacing these juices by means of preserving solutions is known as treatment.

- Preserving solutions are:

i. Creosote: Creosoting is done at temp. 49˚C and 21 kg/cm²

ii. Salt-solution: Chloride of zink (ZnCl2)-process is called Burnettising.

iii. Bichloride of mercury-salt solution (Hg Cl2)-kyanizing

-

2.Metal sleepers:

✓ These are either steel or cast iron, mostly cast iron since it is less prone to corrosion.

- Requirements of metal sleepers:

✓ They should be capable of the tensile and compression stress due to the moving loads.

- Cast iron sleepers:

a. Pot or bowl sleepers
b. Plate sleepers
c. Box sleepers
d. C.S.T 9(Central standard trial)sleepers
e. Rail free duplex sleepers

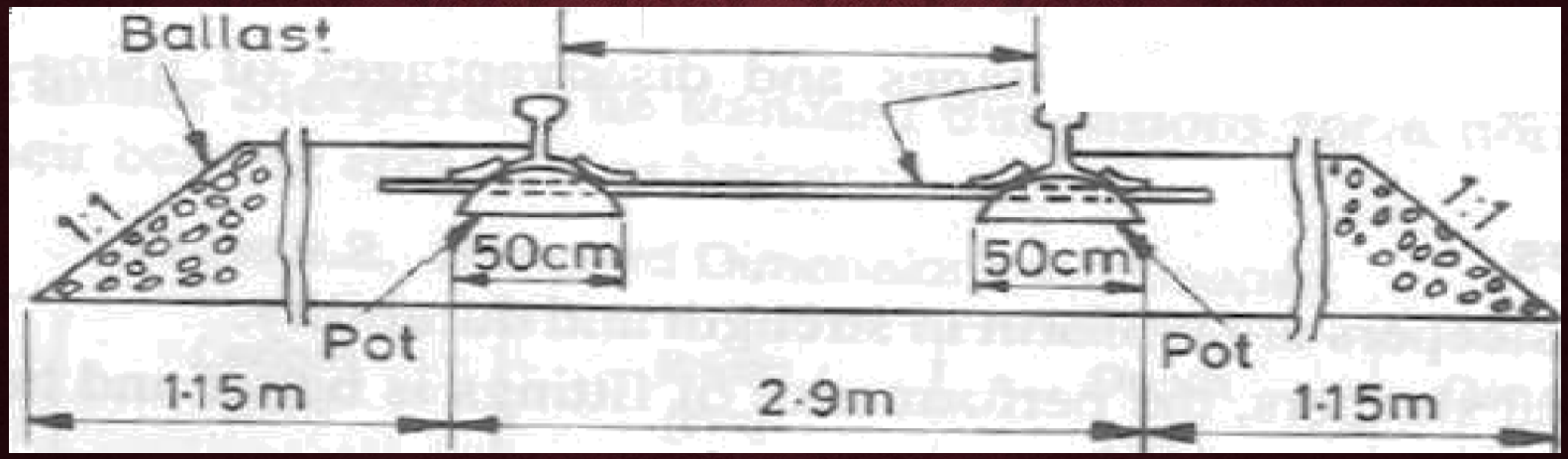
- Pots or bowl sleepers:

✓ They consists of two bowls placed inverted on the ballast.

✓ Effective bearing area 0.232 sq.m is provided under each rail support.

✓ On top of the pot, a rail seat or chair is provided to hold the F.F rail or B.H rail with cant of 1 in 20.

✓ Weight of sleeper is 114 kg. it can be used on curves, sharper than 4˚ on B.G.



- C.S.T-9 (Central Standard Trial-9)sleepers: it is
  - standardized by track standard committee. It has triangular inverted pot on either side on rail seat, a plate with projecting rib and a box on the top of plate.

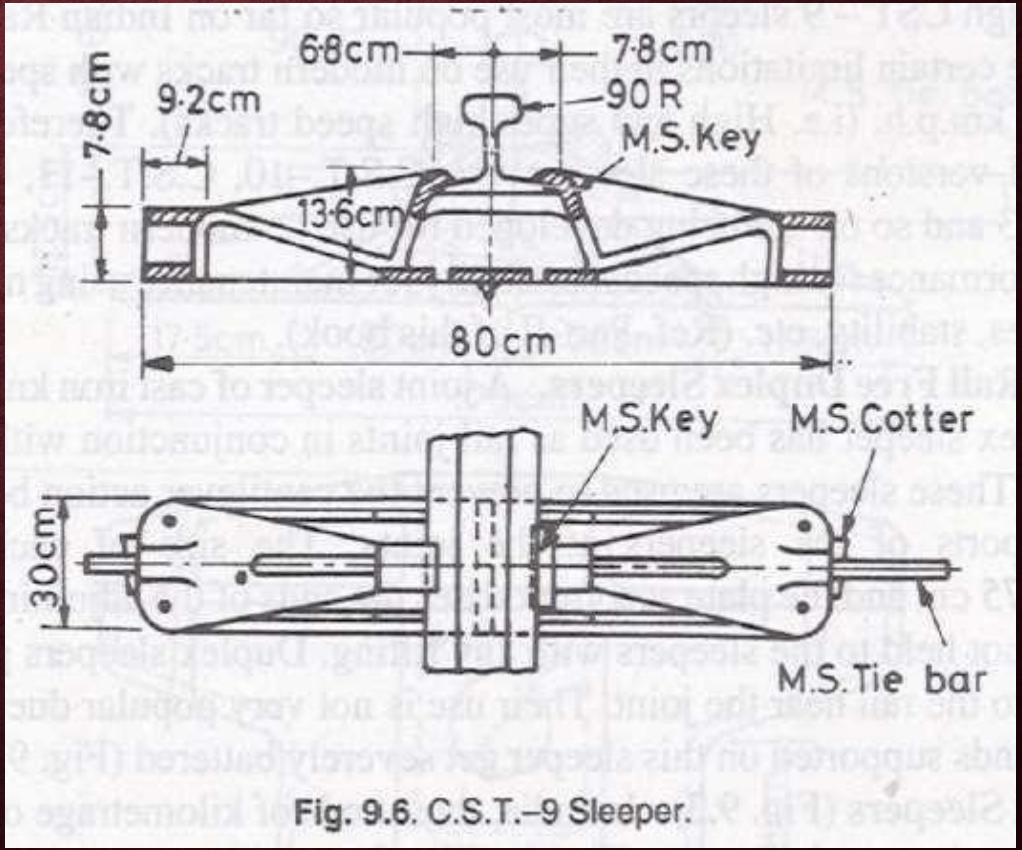


Fig. 9.6. C.S.T.–9 Sleeper.

- C.S.T.-9 sleeper for B.G. weighs 103 kgs. This can be easily assembled as shown in fig.
- Here tie bar is fastened to the plate by means of four standard cotters. Small variation in gauge can be corrected by these 4 cotters.
- Shape of cast iron support in such a way to provide stable base for the rail, lateral and longitudinal stability of track.
- Mild steel two way key is provided to resist creeping movement of the rail.
- Rail seat has 1 in 20 cant and 11.4 cm width in B.G.
- Form rigid track subjected to vibration under moving load without any damping or absorption.
- Suitable for speed up to about 110 kmph.

- Steel sleepers:
- Various types of steel sleepers

1. Key type a) lugs or jaw pressed out of metal
   - b) with loose lugs or jaws

1. Clip bolt type
2. Saddle or spring type.

- Features
  - Fastening to the sleepers are less in numbers and simple in nature.
  - Gauge by use of steel sleepers can be easily adjusted and maintained.
  - Life of sleepers is much more than wooden sleepers.

- Cost is relatively more than wooden sleepers.

Concrete sleepers:

- Two types of concrete sleepers

i. Reinforced concrete sleepers

ii. Pre-stressed concrete sleepers.

- Concrete material is called as ideal sleeper due to

i. They made up of strong homogeneous material.

ii. Impervious to effect of moisture.

iii. Unaffected by the chemical effect of atmospheric gases or sub soil salts.

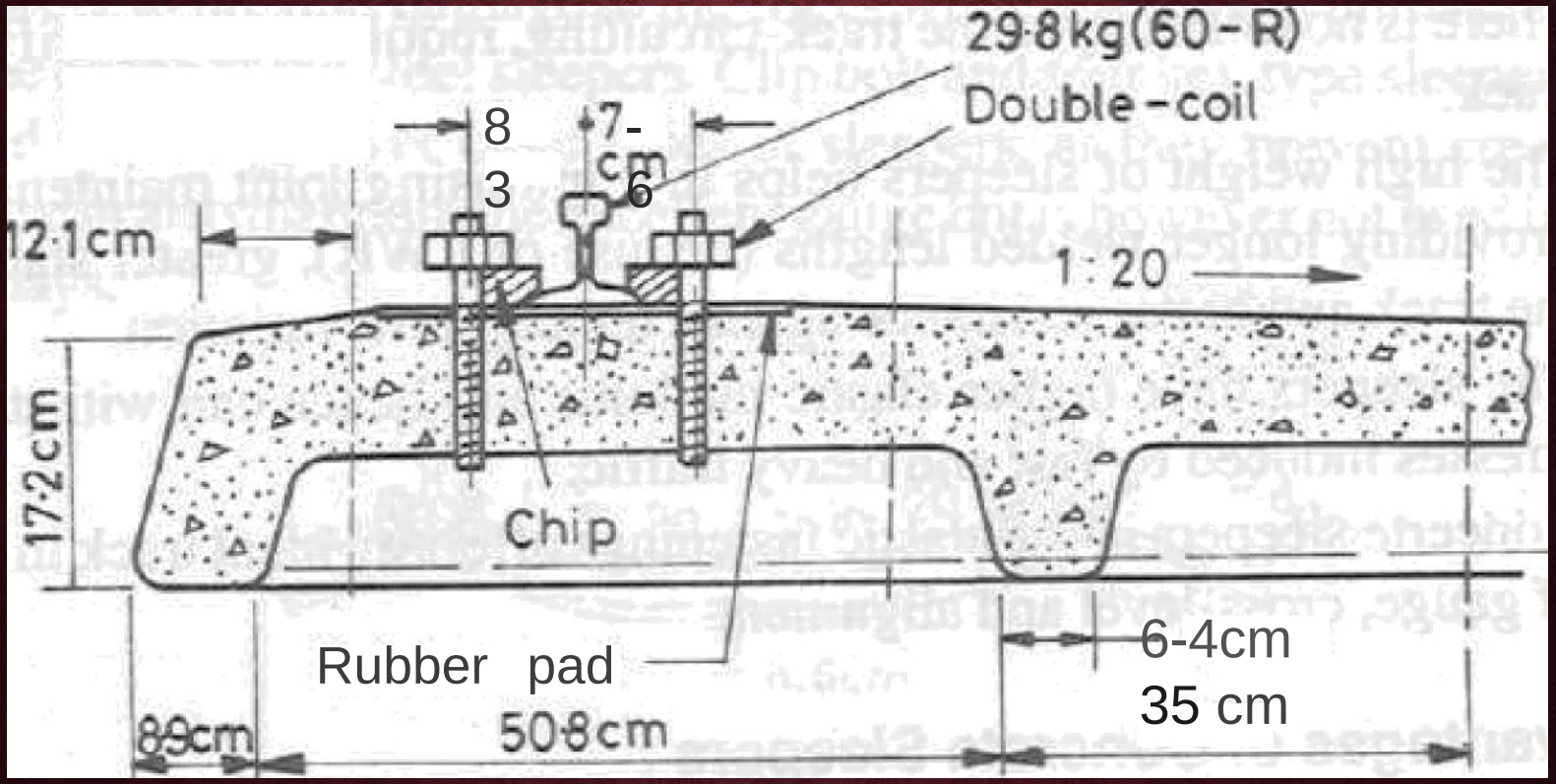
iv. Easy to mould into required shapes to withstand the stresses developed by moving loads.

- Reinforced concrete sleeper: these are 2 types

1. Through type: in this type when concrete sleepers is stressed, cracks on the tension side are inevitable. Though these cracks are very small they tend to enlarge with repetition of the impact loadings of fast trains. This is the major reason for the failure of this sleeper.
2. Composite tie type

- Prestressed concrete sleepers:
  - drawbacks of previous one can be eliminated by this type of sleepers,.

1. In this concrete is put under very high initial compression.
2. The max permissible compressive strength of 211 kg/cm^2.
3. Max. cube crushing strength of concrete in the sleeper is 422 kg/cm^2 at 28 days.
4. Pre-stressed wires are stressed to an initial stress of 8.82 kg/cm^2.


29·8kg(60-R)
Double-coil
8
3
7-
cm
6
12·1cm
1:20
17·2cm
Chip
Rubber pad
6-4cm
35 cm
89cm
50·8cm

Reinforced concrete sleepers

Wooden

- Adzing of Sleepers:
  - In order to obtain an inward slope of 1 in 20 for the rail, sleepers are adzed to form a table at this slope at the rail seat.
  - This process is known as adzing of sleepers. Generally adzing is done for wooden sleepers.
- For smooth and comfortable journey accurate adzing is required.

- Ballast material:

1. Broken stone:

✓ It is the best material for the ballast. Mostly stone ballast is used in all important tracks.

✓ The best stone for ballast is a nonporous, hard and angular. Igneous rocks such as hard trap, quartzite and granite are good material and are used in large quantities for high speed tracks in India.

✓ For stability , graded broken stone ballast is better than ungraded one.

✓ The size of stone ballast should be 5 cm for wooden sleepers and 4 cm for metal sleepers.

2.Gravel or river pebbles or shingle:

- Gravel is second best material for ballast material. Source: river bed, gravel pits.
  - Due to smoothness of the particles these are liable to displace the sleeper and the packing does not hold.

3.Ashes or cinders:

- Earlier this is available in large scale on railways since coal been used in locomotives.
- It can provide excellent properties since it is very porous in nature.
- It is very cheap and can be used in sidings but not in main lines as it is very soft and gets reduced due the wheel load pressure and make the track very dusty.

- Due to its corrosive quality it corrodes the steel sleepers
  - and foot of the rail.
  - But in emergency such as floods ashes or cinders can be used for the repairing formation or packing tracks.

4.Sand:

- It is cheap and provides good drainage. It is particularly good for packing pot sleepers.
- But the drawback is it gets into the moving parts and on the track causes heavy wear therefore leads to high maintenance cost.

5.Kankar:

- It is a lime agglomerate. It can be used where stone is not available. It can be used in road and railways as well. Under the application of loads it will become powder therefore it can be used only in M.G & N.G.

6.Brick ballast:

- Where no stone or other substitutes available it can be used. It can be easily powdered and creates dusty tracks.

7.Blast furnace slag:

- It is a by-product in the manufacture of pig iron forms. The material should be hard and with high density and these are free from gas holes.

8.Selected earth

-

- Size of ballast:
  - The broken stones either of too big size or too small size are found unsuitable for railway ballast.
- Size of ballast depends upon
  - Type of sleepers
  - Maintenance method
  - Location of the track.
    - The size of the ballast used varies from 20mm to 50mm with reasonable proportion of intermediate sizes. The exact size of the ballast depends upon the type of sleepers.
  - For wooden sleepers-51mm
  - For steel sleepers-38mm
  - For under switches, points and crossings-25.4mm

Minimum depth of ballast section:

- The wheel load dispersion in the ballast is assumed at 45˚ to the vertical.
- For uniform distribution of load on the formation, ballast depth should be such that the dispersion lines should not overlap each other.

- Therefore, depth of ballast can be calculated by

- **Sleeper spacing (s)=**

- **width of sleeper(w)+2×depth of ballast**

- Tests on ballast: Ballast material quality is defined by its particle characteristics. Therefore testing of ballast material is required to define these characteristics.
- Tests for ballast material:
- Durability tests:
- Three abrasion tests are mainly using:
  - Los Angeles abrasion: it's a dry test to measure toughness or tendency for breakage of aggregate.
  - It consists 12 steel balls in a large steel drum for 1000 revolutions. Impact of steel balls cause crushing on ballast.
- Material from the test should sieve with 1.7 mm sieve. The LAA value $=((w_1-w_2)/w_1)\times 100$
- Here
- w_1= total weight of specimen
- w_2= weight of material retained on the 1.7 mm sieve.

- Crushing test:
  - To test resistance of an aggregate to crushing under wheel loads.
  - The aggregate passing 12.5 mm IS sieve and retained on 10 mm IS sieve is selected for standard test. Material is placed in a steel mould of 150 ×180 mm deep.
  - Load is applied through the plunger at a uniform rate of 4 tonnes per minute until the total load is 40 tonnes, and then the load is released.
    - Aggregate crushing value = $(w_2/ w_1)\times100$
- Here
- Total weight of dry sample taken = w_1
- Weight of the material passing through 2.36mm sieve = w_2
- Impact test:
  - It measures the toughness to sudden shocks and impact loads.
  - Aggregate size of passing through12.5mm sieve and retained on 10 mm sieve placed in a steel mould.
  - Subjected to 15 blows with 14 kg weight of hammer at a height of 380mm.
    - Aggregate impact value = $(w_2/ w_1)\times100$
- Here
- Total weight of dry sample taken = w_1
- Weight of the material passing through 2.36mm sieve = w_2

- Shape tests:
  - Flakiness index: The flakiness index of aggregates is the percentages by weight of particles whose least dimension(thickness) is less than 0.6 of their mean dimension.
- Elongation index:
  - The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times of their mean dimension. The elongation test is not applicable to sizes smaller than6.3 mm.

- **Bibliography**
  - Text Books: *Railway Engineering* by Saxena & Arora
  - *Airport Engineering* by Rangwala
  - *IRC Codes.*


Thank
you