RAILWAYS

Advantages of Railways :-

1) Political Advantages :-

- Railway has united the people of different caste, religion, custom and tradition.
- Railways have helped in the mass migration of the population.
- Railways have contributed towards development of a national mentality in the minds of people.

2) Social Advantages :-

- Railways has made it easier to reach places of religious importances.
- Railways provide a convenient & safe mode of transport for the country.
- By travelling together without any restriction of caste, the finding of caste difference has disappeared.
- The social outlook of the masses has been broadened through railway journey.

3) Economic Advantages :-

- Speedy distribution of finished product is achieved

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throw Railways.

↳ Mobility of labour has contributed to in the industrial development.

↳ Railways have played the vital role in transporting food & clothes.

↳ Growth of industries has been promoted due to transportation of raw material throw railways.

↳ Railways provided employment to millions of people and thus helped in solving the unemployment problem of the country.

↳ Commercial farming is very much helped by the railway network throughout the country.

4) Techno economic Advantages :-

↳ Higher Safety.

↳ Cost Saving in transportation of long journey.

↳ Efficient land used.

↳ Environmental friendlyness.

↳ Energy Efficiency.

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Classification Of Indian Railway :-

Indian Railways.

- Based On Routes.
  - ↳ Trunk Routes.
  - ↳ Main lines.
  - ↳ Branch line.
- Based on Speed Criteria.
  - ↳ Groups A
  - ↳ Groups B
  - ↳ Group C
  - ↳ Group D
  - ↳ Group G.

Based On Routes :-

1) Trunk Routes :-

Trunk route are main route in railways. The following 6 routes on broad gauge (B.G) and 3 routs of metre gauge (M.G). have been classified in trunk routes.

Broad Gauge => (B.G)

i) Delhi - Mugalsarai - Howrah.
ii) Delhi - Kota - Mumbai.
iii) Delhi - Jhansi - Nagpur - Chennai.
iv) Howrah - Nagpur - Mumbai.
v) Mumbai - Guntakal - Chennai.
vi) Howrah - Vijayawada - Chennai.

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Metre Gauge (M.G) =>

i) Lucknow - Gorakhpur - Guwahati.
ii) Delhi - Jaipur - Ahmedabad.
iii) Chennai - Madurai - Trivantapuram.

2) Main Lines:-

i) All lines other than trunk routes carrying 10 Gross million tones (G.M.T) or more per year for B.G. and max. permissible speed 100 kmph for broad gauge come under main lines.
ii) Trunk relaying period is 20 years for broad gauge and lines other than trunk routes carrying 2.5 G.MT or more per year for M.G. and max. permissible speed is 75kmph for M.G. comes under main lines.
iii) Trunk relaying period is 30 years for M.G.

3) Branch Lines:-

i) All routes carrying less than 10 G.M.T per year for broad gauge and max. permissible speed is less than 100 kmph for broad gauge comes under branch lines.

4) All routes carrying less than 25 G.M.T per year for M.G and max. permissible speed is less than 75 kmph for M.G comes under branch lines.

5) All broad gauge and the metre gauge locomotive engineer only would be permitted to operated on all branches lines of reasonable speed.

Based On Speed Criteria:-

1) Group-A:-

4) Usually trunk routes on which the speed of should be kept at 160 kmph or more curve classified in these should be grouped.
Delhi to Howrah route to Mumbai (C.S.T) via Nagpur.
Delhi to Mumbai Central via kota by Rajdhani route.

2) Group-B:-

4) Those routes on which the maximum permissible speed is 130 kmph.
At Presents B routes comes under group B:-
i) Kalyan to Chennai.

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(ii) Khargpur to Vijayawada.

(iii) Baroda to Ahmedabad.

(iv) Ambala to Pathankot.

3) Group-C :-

↳ All Suburban routes Mumbai, Kolkata & Delhi.

4) Group-D :-

↳ All routes where maximum speed is 130 kmph or present.

5) Group-E :-

↳ The branch lines where maximum speed is less than 130 kmph.

Gauge Of Railway track :-

↳ The gauge of a railway track is defined as the clear distance between inner or running faces of two track rails.

↳ The distance between the inner faces of a pair of wheels is called gauge.

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Types Of Gauge	Gauge width
i) Standard Gauge (B.G).	1.67m
ii) Metre Gauge (M.G).	1.0m
iii) Narrow Gauge (N.G).	0.762m
iv) feeder track-Gauge (L.G). or light gauge.	0.610m

Gauge To Different Countries :-

Sl. No.	Types of Gauge	Gauge width	Countries
1.	Standard gauge	1.435m 1.451m	UK, USA, Canada etc. whole of Europe except Spain and Portugal.
2.	Metre gauge	1.0m 1.069m	France, Switzerland, Argentina, Japan, Australia, South Africa etc.
3.	Narrow Gauge	0.762m 6.10m	India, UK. India & South Africa.

Classification from Surface point of view :-

a) Land transport - Railway, highway, ropeway.
b) water transport - Canal way, Ocean ways.
c) Air transport - Airways.

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Railway Terminology :-

1) Ballast :-

↳ It is the granular material packed under & around the sleeper to transfer load from sleeper to ballast.

2) Gauge :-

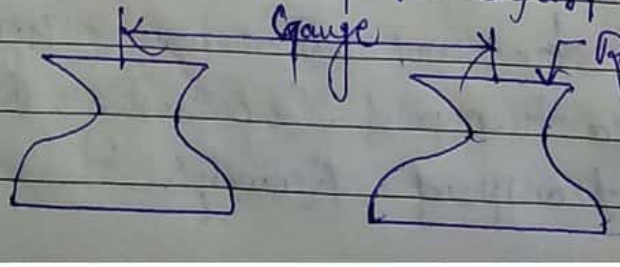
↳ The gauge of a track in India is major of the minimum distance between the inner running or gauge faces of two rails.

↳ It is 3 types i.e.,

i) Broad gauge / standard gauge (B.G) → 1.67m.
ii) Meter gauge (M.G) → 1m.
iii) Narrow gauge (N.G) → 0.762m.

3) Sleeper :-

↳ Sleeper are the member laid traversly under the rails which are meant to support the rails over them & transport the load from rail to ballast.



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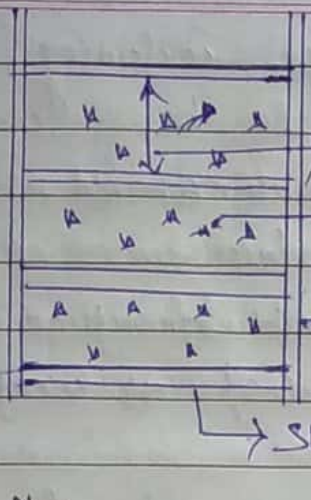

4) Ballast Crib :-

↳ The loose material between two adjacent sleeper.

5) Rails :-

The rails are steel girders which provide the hard and smooth surface for movement of wheels of a locomotive & railway vechiles.

Requirment of An Ideal Permanent way :-

i) Gauge should be uniform & correct.
ii) Rails should be in proper level.
iii) The drainage system must be perfect for enhancing safety and durability of track.
iv) The track should be resilient & elastic should be in order to observation and vibration.

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- The joints, including point and crossing are regarded to be weakest point of the railway track should be properly design & maintain.
- The track should structure should be strong, low in initial cost as well as maintainance cost.
- The various components of the track i.e., the rails, fittings, sleepers, ballast must satisfying the requirement for which they are provided.
- If any component is losing its functioning its requirement then either of it should be replaced and improved.

Railway Track (Permanent way) :-

- Track is a permanent way on which the train runs.

OR,

The combination of rails, fitted on sleepers and resting on ballast and subgrade is called the railway track or Permanent way.

- The rails are joint by the fish plates and bolts and they are fixed to sleepers by different types of fastenings. The sleeper properly placed, resting on ballast.

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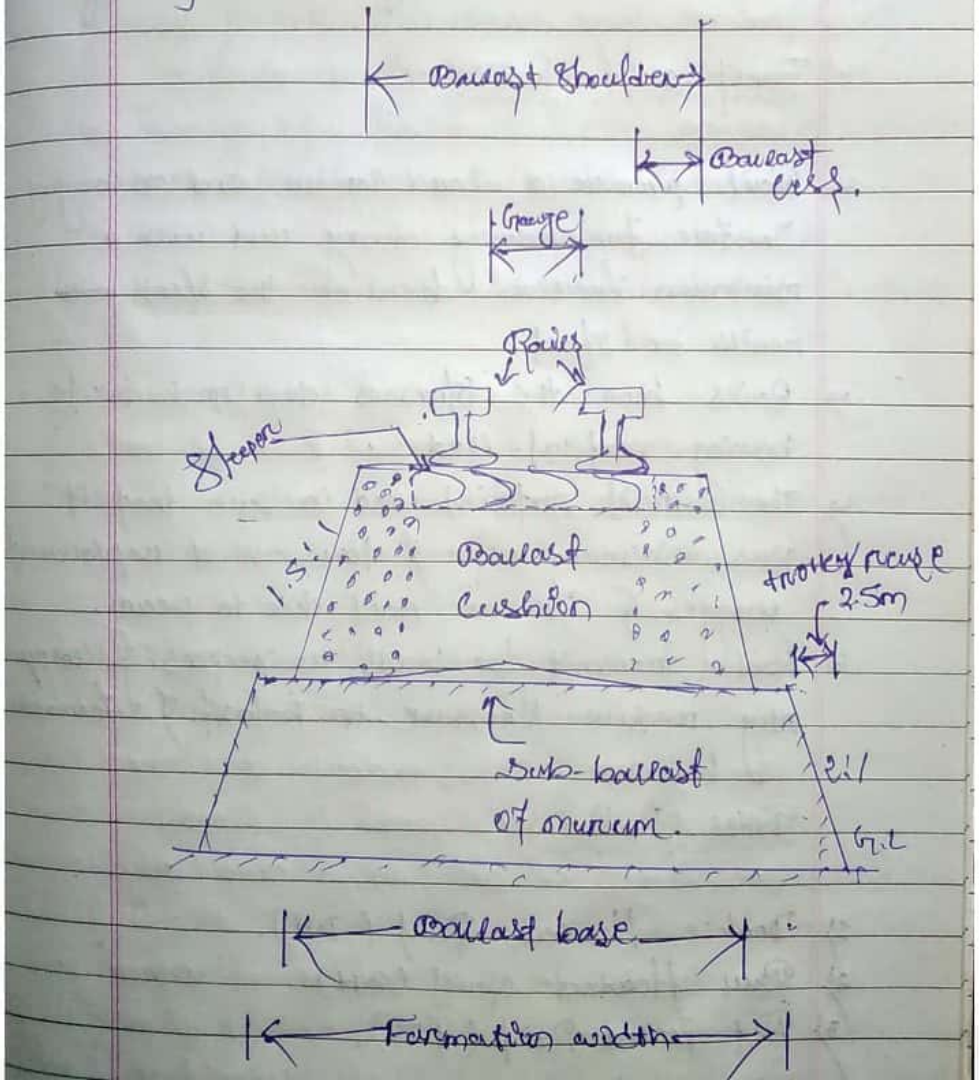
The layer of ballasts rests on the prepared sub-grade called the formation.

The hole function of rails is to be transfer the load to the sleepers, from sleepers the load is again to the ballast from ballast it further goes down to the formation and then to the natural soil.



Rails :-

The rails on the track can be considered as steel graders for the purpose of carrying axial load. They are made up high Carbon steel to withstand wear and tear. Flat footed are mostly used in railway track.

Functions Of Rails :-

1) Rail provide a hard smooth and non changing surface for heavy moving load with a minimum friction between the steel ~~with~~ rails and steel.
2) Rails bear the stresses developed due to having vertical load.
3) The rail material used in such that it gives minimum wear & tear avoid replacement charges & failure rail due to wear.
4) Rail transmit the loads to sleepers & consequently reduce pressure on ballast & formation below.

Types Of Rails :-

1) Double Headed Rail (D.H).
2) Bull Headed Rail (B.H).
3) Flat footed Rail (F.F).

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1) Double headed rails :- (P.T.)

- It consists of 3 types i.e.,
  a) upper table.
  b) web.
  c) lower table.

- upper and lower table are identical.
- Long contact with chairs made the surface of lower table very rough & smooth
- running of trains is not possible with it. Now, practically out of use.
- Length varies from 6m to 7.32m.
- Wrought iron are used to manufacture for these rails

2) Bull Headed Rail :-

- The rail sections having their head or more dimensions than that of their foot are known as bouy headed rails.
- These rails are consists of -
  a) Head.
  b) web.
  c) Foot.
- The foot is designed only to properly hold the leaden key with which the rails are secured to chairs.
- Only to provide necessary strength to the rails two cast iron chairs are required

for each Sleeper.

- Extensively used in England and in some of Europe.
- weight of standard rails of this types is 47kg per on main lines and 42kg for branch lines.
- Length of rails is generally 18.29m.

3) Flat footed Rails:-

- Invented by Charles Vignoles in 1836 also called as Vignoles Rails.
- In this type of rails, foot is spread out to form base.
- Highly popular and most used in railways 90% of the present railway track consists of flat footed rails.

Rail joints:-

Rail are necessary to hold together the adjoining ends of the rails in the correct position both in the horizontal & vertical plane.

Requirments of an Ideal joint:-

i) It should be as strong as other portion of the train

ii) It should have just enough rail gap

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between the two Rails.

iii) It should have the same elasticity as the other portion of the track.

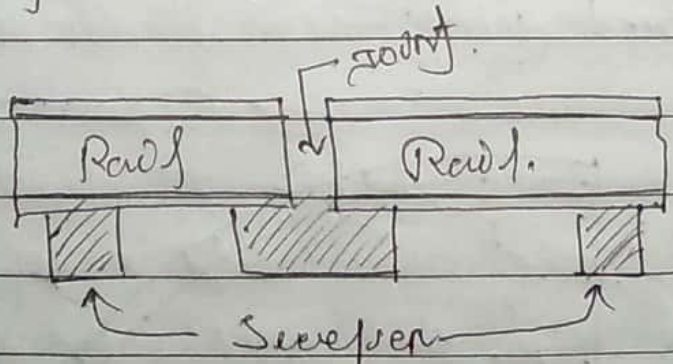
iv) It should be provide facility of removal & replacement.

v) The ends of the joint should not get battered.

Types of Joint:-

1) Supported Joint
2) Staggered Joint.
3) Suspended Joint.
4) Bridge Joint.
5) Square or even joint.
6) Compromise Joint. (Joint by fishplate & fish bolt).
7) Bonding Joint.
8) welding Joint.

1) Supported Joint:-



The rails ends are rest on a single sleeper only.

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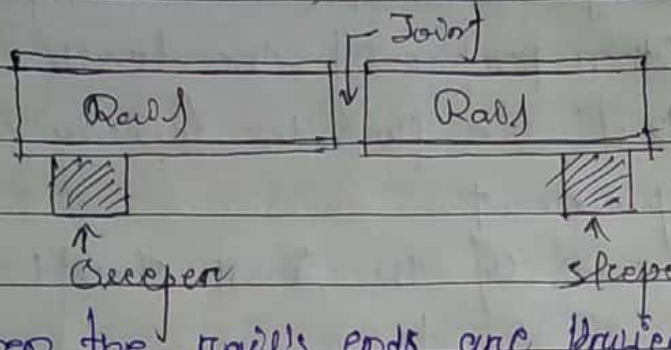
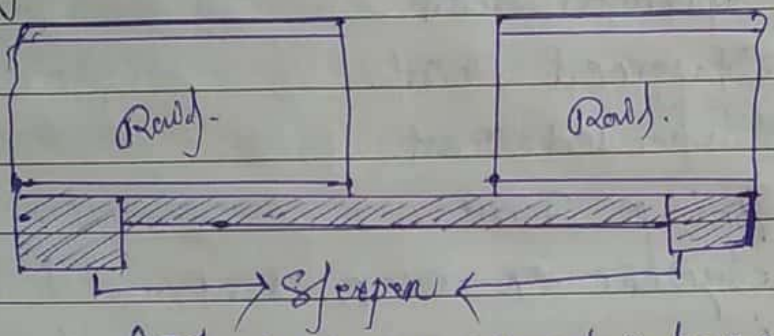
3) Suspended Joint :-



when the rail's ends are projected beyond the sleeper

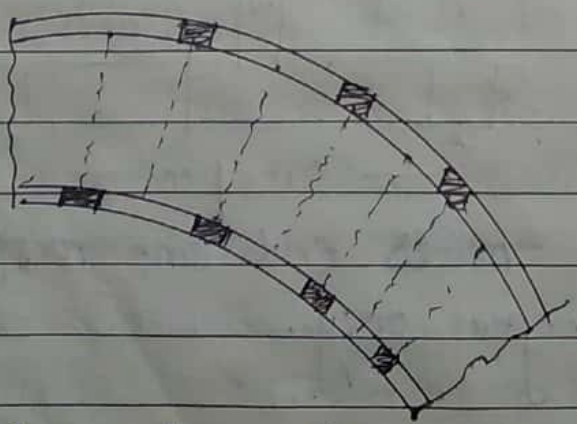
4) Bridge Joint :-



(Straight or waved out as a bridge)

when the suspended rail joints are connected by flat or a plate is known as bridge joint.

2) Staggered joint :-



In this joint the position of rail joint are not opposite to each other side.

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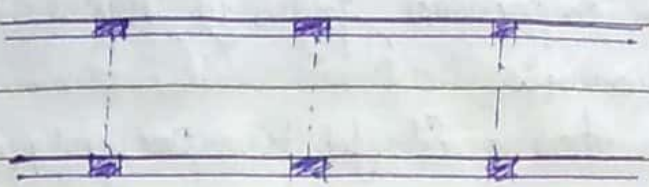
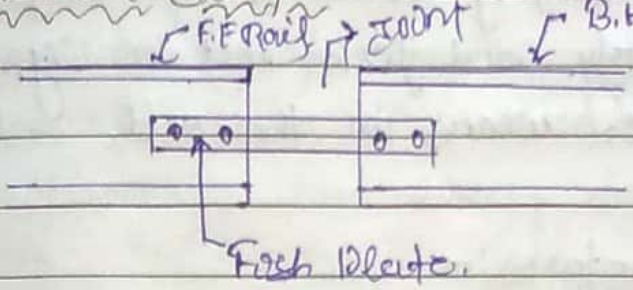
5) Square or Even joint :-



It is just the opposite of staggered joint. It means in this joint the rail joints are opposite to each other.

6) Compromise joint :-



when two different rails required to joint together, by a fish plates is known as Compromise joint.

7) Insulated Joint :-

when insulating medium is inserted in a rail joint to stop the flow of current.

Wear of Rails :-

The flow of rail metals due to heavy loads is known as wear of rails.

The following precaution must be taken for reducing wear's of rails are -

a) The rails should be replaced, when it looses its weight more than 35.00 lbs ordered

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width.

ii) The expansion gapes of Rails joints should be minimum.

iii) The track should be properly maintain with special attention to the joint.

iv) The heavy mineral oil should be applied on the top of the rails to minimised the corrosion of rail metal.

v) The ballast under joint should be placed properly and fish bolt be tightened to reduce wears in the end.

Advantages:-

Chairs → No chairs are required on this form of rails foot of rail is directly spikes to sleepers.

Stiffness → This form of rail is more stiffer both vertically and laterally than the bull headed rail of equal weight.

Kinks → Less liable to develop kinks and provides a uniform and more regular surface than bull headed rails. The flat footed rails are found to be cheapere than the bull headed rails.

Load distribution → The flat footed rail distribution the train load over a great member of sleepers. This results in greater

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track stability. Longer & liter than bull headed rails.

Standard Rails Section → Rails designated by its weight for unit length.

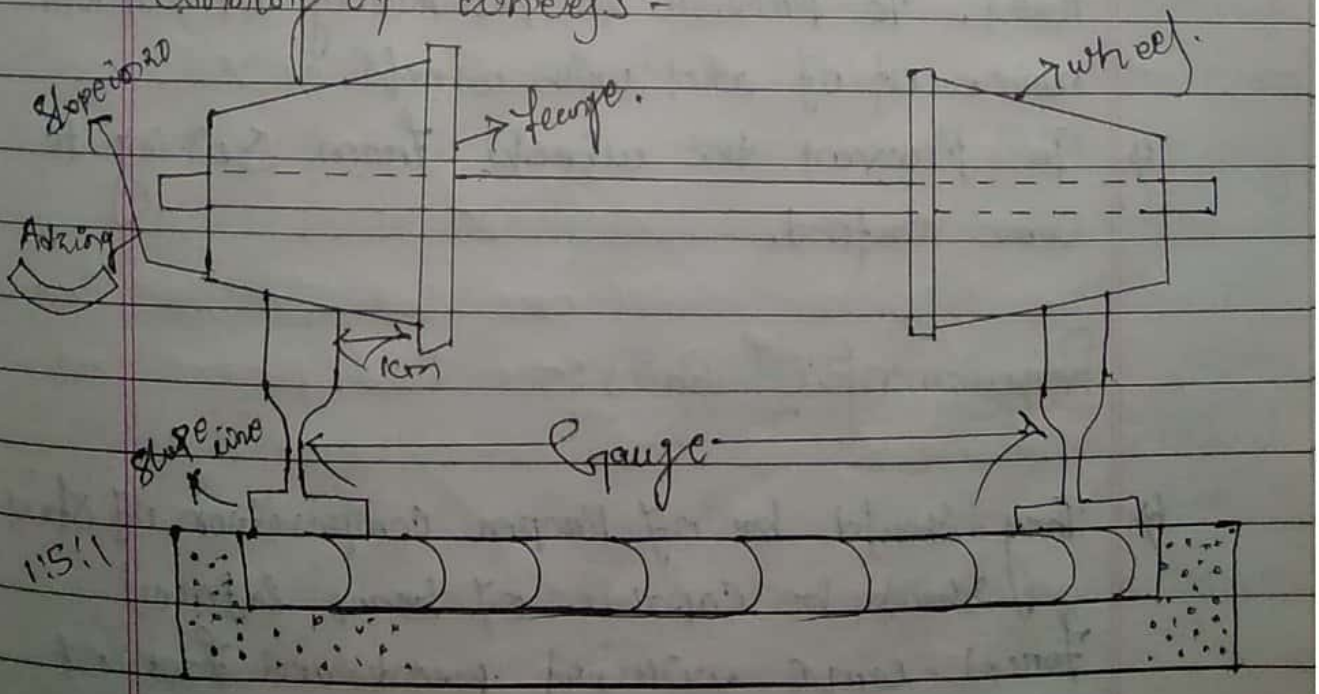
Ex:- Bergson or BG/BG gauge etc.

weight and Section of rails governed by many factors.

a) Gauge of track.
b) Maximum permissible speed.
c) Type and Spacing of sleepers.
d) Depth of ballast cushion.
e) Heaviest moving load likely to move over the rails.
f) Spacing of sleepers.

Advantages Of Railway :-

Coning of wheels -



- The distance between the inside edges of wheel flange is generally kept less than the gauge of the track.
- So there is a gap between the wheel flanges and running edges of the rails nearly equal to 1cm on either side.
- Normally the tread of wheel is absolutely dead Central of the head of the rail, as the wheel is conical to keep it in this Central position automatically. These wheels are given a slope of 1 in 20.

Advantages :-

- To reduce the wear and tear the wheels flanges and rails which due to rubbing action of flanges with inside faces of the rail. To Provide a possibility of lateral movement of axel with wheels.
- To Prevent the wheels from Sliping to Some extend.

Requirment Of Rails :-

- They should be of Proper Composition, of steel should be Capable of beam lateral forces large width of head and foot of the rails with high lateral stiffness.

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- Foot should be wide enough so that rails are stable against overturning especially on curve.
- Bottom of the head and to the foot should be so shaped as to enable the fish plates to transmit the vertical load from the head to the foot at the rail joints.
- Web of rails should be sufficient thick to bear the loading coming on it.
- Relative distribution of load at web rails in of rail and web for smooth transmission of load.

Buckling of Rails:-

Buckling means the track has gone out of its original position on alignments due to prevention of expansion of rails on hot weather on account of temp. variations. Buckling may take place on tangent length and at curves.

Causes:-

- when expansion gap is not sufficient the force of expansion throws the track out of position resulting in bending of rails known as buckling.
- The fish plates being bolted so tight that

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the rails are not allowed to slip expand.

Prevention:-

↳ The fish bolts should not be tightened too hard as to prevent the expansion on construction of rails. Expansion gap should be provided by taking into account the expansion of rails due to rise in temp in that region.

↳ The ballast section sleeper density and the rail section must be checked for design and redesigned for safety under various stresses.

Hogged Rails:-

Due to buttering action of wheels on the end of the rails, the rails get down and get deflected at the ends these rails are called Hogged rails.

Cropping:-

In this the rails are cut-off and fresh holes for fixing the fish plates are provided.

Replacing:-

In this hogged rails are completely removed and replaced by new rails.

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but it ~~is~~ uneconomical.

Welding :-

Hogged rails are brought to the level by welding over the cut or bent position at the ends.

Scrapping :-

This is the method of straightening the end by means of a scrapping machine but it does not gives satisfactory job. So cropping is only possible way.

* Kinks in Rails :-

↳ When the ends of adjoining rails move slightly out of position, kinks are formed.

↳ Kinks may from due to the reason of loose packing of joints.

Rail Failures :-

1) Crushed Heads :-

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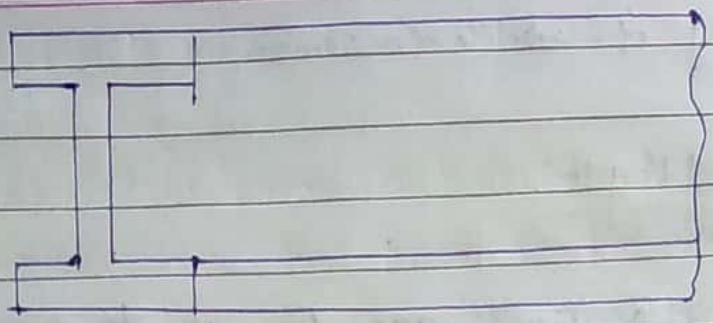


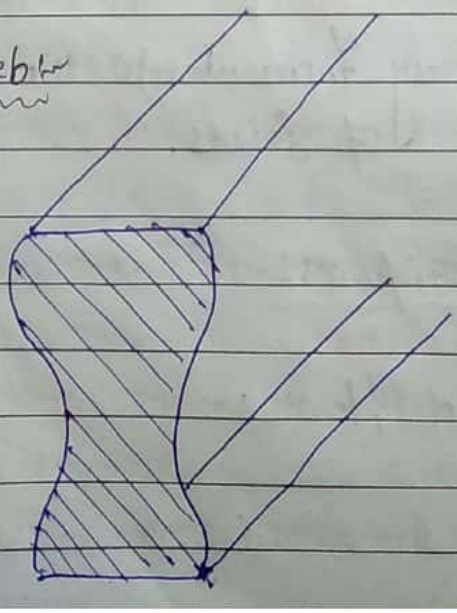
Crushed heads are have either Sagged or flattened. Crushed heads are due to,

- Slipping of wheels.
- Flat Spots on wheels which are developed due to Skidding of wheels.

2) Square or Angular Break :-

The rail may be Completely broken either in a vertical plane or in a inclined planes.

3) Split web :-



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This is the crack through the web.

4) Horizontal Fissures :-

These are developed in the rail head and they are more form of failure and increases gradually / developed gradually.

5) Transverse Fissures :-

This is the most common cause of rail failure in America.

It is a crack which start form a point inside the heads and spread gradually.

Sleepers :-

Functions of Sleeper :-

- To hold the rails to correct gauge (i.e. exactly in straight & flat curves).
- To holds the rails in proper level or transvers & tilt. i.e. levels in turn out and crossovers etc.
- To distribute the load to the ballast.
- To support the rails at a proper level in straight track & at proper superelevation & the proper curve.

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Requirements of Sleepers:-

- It should provide sufficient bearing area for the rail & the ballast.
- The rail should be easily fixed and taken out from the sleeper without moving them.
- It should be strong enough to withstand the bending stresses.
- It should be economical in respect of initial cost & maintainance cost.
- It should be capable of maintaining alignment of track & level of ballast.

Types of Sleepers:-

1) Wooden Sleepers:-
These sleepers referred as the best because they fulfil almost all the requirements of an ideal sleepers.

Advantages -

- It is used for highspeed
- " " " " coastal & salty area
- Easy to lay, lift, pack & maintain.
- These are economical.

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- Fitting for wooden sleepers are few & simpler to design.

Disadvantages:-

- Minimum service life 12-15 years, as compare to other sleepers.
- Due to moisture content in timber, it affected the railway track.
- Due to limited no. of trees, now a days these type of sleepers using in lesser quantity.

ii) Steel Sleepers:-

These sleepers fixed on the track with sufficient length with the help of nut end bolt.

Advantages:-

- Service life is 20-25 years.
- This avoids the connection between rail & sleepers due to which we need not change it again & again.
- High speed.
- Can handel heavey load.

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Disadvantages:-

a) Can't use in coastal & salty area because it corroded easily.
b) It is very costly.
c) Due to breakage of rail and bolts these sleepers can't be use again.
d) Due to good conductor, form coach it can be used in track circuit area.

iii) Concrete Sleepers:-

These sleepers were ended due to chronic shortage of wooden sleeper & need for better design and economics of sleepers on sustainable basis.

These sleepers are mainly two types, i.e.,

a) Reinforced concrete sleepers.
b) Pre-stress concrete sleepers.

Experiments have been conducted in India and abroad and proven that concrete is an ideal material for the sleepers for following reason.

a) They are made of a strong homogeneous material.
b) Impervious to effect of moisture.

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c) Unaffected by the chemical attack of atmospheric gases or soft soil salt.
d) It is molded easily to size & shape.

Advantages :-

- These sleepers are free from natural decay.
- And attacks by insects etc.
- They have maximum life (40-60 years) when compare to other sleepers.
- This is not affected by moisture.
- There is no difficulty in track circuiting, required for electrifying the track.
- Concrete sleepers offers an ideal track in respect of gauge, and alignment.

Disadvantages :-

- The weight of concrete sleeper is high 2.5-3 time to wooden sleepers.
- These sleepers required more handling.
- To damage to these sleeper is very heavy in case of derailment.

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Sleeper Density :-

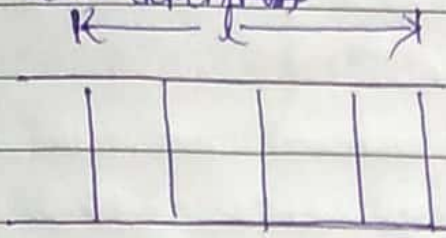
↳ The number of sleepers per rail ~~gauge~~ length.

↳ It denote by (M+x) or (N+x).

where,

M = Rail length

~~x is depend on~~



x is depend on type of section of rail.

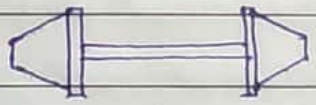
ii) Speed

iii) Nature of formation.

iv) Types of Ballast.

v) Strength of Sleeper.

vi) Axle load.



In Indian railway we used sleeper density between (M+13) to (M+7).

Q. Find out the expression for sleeper density for B.G. track if 19 sleepers are used under a rail length.

$19 = (M+x)$

$\Rightarrow 19 = 13+x \Rightarrow x = 6.$

∴ Expression for sleeper are,

$= M+x = M+6.$

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Ballast:-

Ballast is a granular material usually broken stone, brick, kankar, gravel or sand placed and packed below around the sleepers to transmit transmit the load from sleepers to formation.

Function Of Ballast:-

- It transfer the load from sleeper to sub-grade.
- Hold the sleepers in position & prevent lateral and longitudinal movement due to dynamic load and vibration moving train
- Provides easy maintaining the correct level of two track i.e., (level in straight portion & correct superelevation on curve) and correcting track alignment.
- Provides good drain foundation below the sleeper.

Requirement Of good Ballast Sleepers:-

- Should be able to hand packing disintegrating.
- Should be resists crushing under dynamic load.
- Should allow for easy drainage width

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minimum Sokage the void should be large enough to prevent capillary action.

- Should not make the track dusty and muddy due to powder under dynamic wheel loads but should be capable of being clean to provide good drainage.
- The ballast should be available at near by quarries show that it reduce the cost of supply. It should be also fulfill the requirement of quality, amount of traffic, life & maintainance cost.
- Should not produce any chemical action with rail and metal sleepers.
- The size of track ballast should be 5cm for wooden sleepers, 4cm for metal sleepers and 2.5cm for turnout and Crossovers.

Types Of Ballast:-

1) Broken Stone Ballast:-

This is the best material for the ballast & almost all imp track are provided with stone ballast

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ii) Gravel or River Pebbles or Shingle:-

Gravel comes next in rank for its suitability for use as ballast and is used in large quantity in many countries. This is obtain either from river beds or from gravel pits.

iii) Ashes or cinders:-

This material is available in large quantities on railways from coal being used in locomotives.

iv) Sand:-

It is reasonaly good material as ballast as it is cheap and provides good drainage.

v) Kankar:-

It is lime agglomerate which is common in certain clayey soil and is ~~deposit~~ deposit of the ground.

vi) Blast Furnace Slag:-

It is a by product of pig in manufacture irons form a suitable ballast materia

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vii) Moorum:-

It is recomended ballast for sleeping and when they nearly laid.

viii) Brick Ballast:-

when best stone or substitute available for used as ballast, over burnt are broken into small size and used it powdery easily and produce a dusty track. Rally of tracks laid on brick ballast many a time get corrugated. Brick ballast however is found to be a good for drainage.

Quantity of Ballast:-

The quantity of stone ballast required for per metre tangent length is 1.056 m^3 for B.G, 0.71 m^3 for M.G & 0.53 for N.G with standard ballast.

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For Curves with Superelevation, the quantities of ballast is slightly more, because as per Indian Standard, recommended depth at level is provided under the inner edges of the sleepers. moreover wider shoulders about (15cm or more) than specified above at provided on outside Curved to counteract the increased lateral thrust.

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Track Fittings

1) Fish Plate
2) Spike -
   - Dog Spike
   - Screw spike.
   - Round Spike.
   - Elastic Spike.
3) Bolt. -
   - Dog or hooked bolt.
   - Fish bolt.
   - Rag bolt.
   - Fang nut & bolt.
4) Chairs -
   - Cast steel chairs.
   - mild steel and cast iron slide chairs.
5) Blocks :-
   - Distance blocks.
   - Heel block.
   - Crossing block.
   - Check block.
6) Keys :-
   - wooden key for cast iron chairs.

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↳ Morgan Keys.
↳ Cotters And the bar.

7) Plate –
↳ bearing Plate.
↳ Shielded Plate.

Fish Plate :-

↳ It is used in rail joint to maintain the continuity of the rails and to allow for any expansion or contraction of the rail caused by temp variation.

Requirment Of Fish Plates :-

i) They must Support the underside of the rails and top of the foot.
ii) They Should allow a free movement of rails for expansion and Contraction, for this purpose, they should not touch the web of the rail.
iii) They Should hold the end of the rail laterally in line and vertically level. They should be provide against the wear of fish plate due to impact, expansion & contraction.

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Failure of Fish plate:-

i) Abrasion on top of fish plates, spacing along central half length.
ii) Cracking develop along the fastening and these may extend upto top and bottom of fish plate.

Spike:-

For holding the rails to the wooden sleepers spikes of various types are used.

Requirements of A Good Spike:-

i) The spike should be cheap in cost.
ii) The " " " easily fixed & removed from the sleepers.
iii) The spike should be as deep as possible for better holding power.
iv) It should be capable of maintaining the gauge.
v) The spike should be strong enough to hold the rail in position.
vi) Dog spikes:-

For holding the ~~foot~~ footed rails to a wooden sleepers, dog spike are commonly used.

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The shape of the head of spike resembles with ear of dog, hence it is named as dog spike. The section of spike is square shape and bottom part is either pointed or chisel shape. They are cheapest, easy in fixing & removing from sleepers & maintain a batter gauge than screw pipe. The only disadvantage of the dog spike is that due to web motion of the rail, the dog spike are slightly driven out of the sleeper which reduces the pressure on the foot of the T.F rails, resulting in creep occurrence.

For proper use of dog spikes, the following point to be remember,

1) Holding power of pointed dog spikes at bottom is maximum.
2) The holding power of dog spikes is less than 50% of the holding power of screw pipe, but its use is more than screw spike. Due to it cheapness, easy fixation and extraction and batter hold of the gauge.
3) 4-6 spikes per sleeper depending upon light to heavy traffic on tangent track & 6-8 spikes per sleepers on curves.
4) Dog spike on sleeper should have staggering position, otherwise the rails

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due to less holding power would have a tendency to move out of position, resulting in change in gauge which may be dangerous.

Round Spikes :-

These spikes with bare head either cylindrical or hemispherical are used for fixing the chairs of B.G. rails to wooden sleepers.

Standard Spikes :-

These are used for cast iron chair only to fix them with timber sleepers.

Screw Spikes :-

These are the screws with 'V' threads used to fasten the rails with timber sleepers. The head is circular with a square position.

Screw spikes have more than double the holding power to that of dog spikes. However the screw spikes are costly & with that more use, the gauge maintenance is more difficult, so that the dog spikes are preferred than screw spikes.

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Gradient :-

-> It is one type of Slope.

Geometric design of Structure

The most of the train derail due to,

- Track defect.
- Vehicle effect.
- Operation effect.
- Gradient.

The gradient are provided because of following possibility,

i) To reduce the cost of earthwork.
ii) To reach various station, location at different elevation.
iii) To provide a uniform rate of rise or fall as far as possible.

Ruling Gradient :-

-> which determine the max. load that can engine can haul in the section.

-> Max. gradient allow in the terrain &
- i) plain terrain - 1 in 150 to 1 in 200.
- ii) Hilly terrain - 1 in 100 to 150.

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Momentum Gradient:-

These are the gradient on a section which are steeper than the ruling gradient and do not determine.

Pusher or helper Gradient:-

In mountainous region instead of limiting train loads, it may be operationally easy and economical to run train based on loads it can carry on remaining track by use of assisting / pusher / banking engines for several gradient portion.

Gradient in station yard:-

i) To prevent the movement standing vehicle on track.
ii) To prevent additional resistance due to grade on the starting of vehicle.

Grade of compaction:-

In order to avoid beyond the allowable limit gradient and reduce these relocation called grade compaction.

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$$D = \frac{1719}{R}$$

where,

D = degree of curves.

R = Radius of Curves.

For B.G.,

0.04% per degree on $\frac{70}{R}$.

For M.G.,

0.03% per degree on $\frac{52.5}{R}$.

For N.G.,

0.02% per degree on $\frac{35}{R}$.

Q) If the rolling gradient is 1 in 120 on a particular section of B.G. at the same time curve of 4° is situated on these rolling gradient. Find out allowable rolling gradient.

Given data,

Rolling Gradient = 1 in 200.

For B.G.

B.G. Grade compaction = 0.04 × 4

= 0.16%.

Rolling Gradient = $\frac{1}{120} \times 100$

= 0.83%.

∴ Allowable Rolling gradient = 0.83 - 0.16

= 0.67%.

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Points & Crossing

Points and Crossing :-

-) Points, crossings, turnouts, cross-overs, these are related terms on arrangement made in the railway tracks by which the train can move from one route to another.

Necessity Of Points And crossing :-

i) Its provide flexibility of movement by connecting one line to another according to requirement.

ii) They also help for imposing restrictions over turnouts which necessarily retard the movements.

Turnout :-

-) It is the simplest combination of points & crossings which enables one track either a branch line or a siding, to take off from another track. So, the object of turnout is to provide facilities for safe movements of trains in either direction on the both tracks.

-) The following are the parts of turnout :-

i) A pair of points or switches (ABCD and EFGH).

ii) A pair of Stocknails.

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iii) A vee crossing (GUIDES).
iv) Two check rails.
v) Studs or stops.
vi) Four lead rails.
vii) 'Switch tie-plate' or gauge tie plate of crossing tie plate.

Important terms used in Point & crossing:-

i) Facing Direction:-

If Someone stands at toe of Switch and looks towards the crossing, then the direction is called "facing direction".

ii) Trailing Direction:-

If Someone stand at Crossing and looks towards the Switches, then the direction is called "Trailing direction"

iii) Facing of Points of Turnouts:-

Those where trains pass over the Switches first and then they pass over the crossing.

iv) Trailing Points of Turnouts:-

These are on the opposite sides of facing points in which the trains pass

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over the crossing first & then over the switches.

iv) Right-Hand And left-Hand Turnouts:-

If a train from main track is diverted to the right of the main route in the facing direction then this diversion is known as Right-hand turnout.

If a train from main track is directed to the left of the main route in the facing direction, then the diversion is known as left-hand turnout.

v) Right-Hand & left-Hand Switches:-

These are termed as left hand or right-hand switches depending upon left or right when seen from the facing direction i.e, stand at the points and look towards the crossing.

Crossing:-

A crossing or a frog is a device which provides two flangeways through which the wheels of the flanges may move, when two rails intersect each other at an angles.

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Components parts of Crossing :-

i) A crossing or vee piece.
ii) Point and Splice rails.
iii) wing rails.
iv) check rails.
v) Fixings at toe of at heel.
vi) Blocks at throat, at nose, at heel and distance block.

Requirements And Characteristics Of A Good Crossing :-

i) Crossing has to be rigid & stand against severe vibrations.
ii) The nose of crossing should have some thickness. This thickness varies from 6mm - 18mm. In India, the practice is to make this thickness equal to the thickness of web of the rails.
In America, standard thickness of 1.25 cm is adopted.
The distance between theoretical nose of crossing (T.N.C) and Actual nose of Crossing (A.N.C) for practical purposes is equal to Nose thickness × numbers of crossing.

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Type of Crossing :-

On the basis of shape of crossing -

1) Acute angle crossing or 'V' crossing or Frog.
2) Obtuse angle crossing or Diamond crossing.
3) Square Crossing.

1) Acute angle Crossing :-

This crossing is obtained where a left hand rail of a track crosses a right hand rail of another track & vice versa. If the angle of intersection of the approaching rail is acute angle, it is termed as acute angle crossing. It consists mainly of point and splice rails, wing rails and check rails.

Points & Splice rails :-

An acute angle is formed either by a point rail & a splice rail or by combination of two point rails.

A pair of wing Rails :-

These are bends at the ends. One end of the wing rails is connected to lead rails whereas the other end is flared.

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A. Pairs Of Check Rails :-

These are parallel to the running rails. They are flared at end for guiding the wheel flanges.

2) Obtuse Acute Crossing :-

These crossing is obtained when lefthand rail of one track crosses right hand rail of another track or vice versa at an Obtuse angle.

In diamond Crossing, a pair of special Crossing is used which is called obtuse Crossing.

3) Square Crossing :-

When two straight tracks cuts each other at right angles, they gives rise to Square Crossing.

On the basis of Assembly of crossing :-

1) Spring or movable wing Crossing.
2) Ramped Crossing.

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1) Spring or Movable Crossing :-

In such crossing, one wing rail is movable & is held against the vee of the crossing with a strong helical spring.

2) Ramped Crossing :-

In case of complicated yard layout with heavy but slow speed traffic, the throat to nose clearance is negotiated by use of special manganese steel blocks over long distances.

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Maintaince Of Track

Maintenance Of Track :-

Necessity Of Maintenance :-

Track maintaincance becomes a nessesity due to following reasons :-

i) Due to constant movement of heavy and high speed trains, the packing under the sleepers becomes loose & track geometry gets disturbed.

ii) Due to the variations of impact of high speed trains, the fittings of the track come under & there is heavy wear & tear of the track & its component

iii) The track structure has to bear too many others effects due to corrosive, speed & load panterrelancy on curves, points & crossing bridge approaches etc.

Therefore, it becomes nevessary to maintain a railway track for its smooth running, safely & efficiently at specified speeds.

If the track is not maintained, it will be fasten in wear & tear, rough riding &

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discomfort to the passengers & them which may result to the derailment of trains.

Advantages Of Good Maintenance :-

1) If the track is properly maintained, the life of both the track as well as the rolling stock increases & there will be lesser wear & tear of their components.
2) Regular tracks maintainance helps in reducing operating costs & fuel Consumption.
3) Safety to passengers & good encourages the use of railway & better earnings.

Methods Of Maintainance Of Railway Track :-

The maintainance of railway track can be carried out either manually or by use of mechanical appliances or by a combination of both i.e. machine & labour.

Maintainances of track can be devided into two parts.

a) Daily maintenance.
b) Periodic maintenance.

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a) Daily Maintenance:-

It is carried out by the day time staff maintained throughout the year. The use of maintainance gauge are along the railway track, is made. The railway track is devided in suitable section of 5-6 km of length. One gauge is attached to each section for maintaining that section in good condition.

b) Periodic Maintainance:-

Periodic maintainance is carry out after an interval of two or three years. During Periodic maintainance, the gauges level, alignments, points & crossing etc, are throughly checked, the defect are detected, the causes are determined & the residual measures are taken.

The maintainances of track includes the following items of maintainance in good condition -

i) Surface of Rail.
ii) Track-alignment.
iii) Gauge.
iv) Proper Drainage.
v) Track Components.
vi) Bridge & its approaches.

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vii) Rolling Stock.
viii) Points & crossing.
ix) Level Crossing.
x) Tunnels.

Briefly describe the various duties of a Permanent way inspector (PWI) :-

The PWI is generally responsible for the following -

i) Maintainance & inspection of the track to ensure satisfactory & safe performance.
ii) Efficient Execution of all works incidence to track maintaince, including track relaying work.
iii) Accounts & periodical verification of the stores & tools on his or her charge.

The PWI should also carry out inspections of the following -

Testing of track :-

He or she should run a test check on the foot plate of the engine of fast moving at least twice a month & on a rear brake van of a fast vechile once a month, & oversee a note of sections

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where is quality of running is defective & get them rectified.

Inspection of Track & Gangs :-

The PWI should inspect the entire section with the help of a push trolley at least once a week more once of on if necessary.

Level Crossing Inspection :-

① He or she should check the equipment assigned to the gateman (Head of the gang) once a month.

② He or she showed ensure that any level crossing are safe.

Point & Crossing Inspections :-

The PWI should inspect the point & crossing of passenger lines once in 3 months & those in other lines once in 6 months.

Curve Inspections :-

The PWI should check the Superelevation of each curve once in 6 months. Based on his or her observation, the PWI should

take the appropriate action to correct the curve, if necessary.

Safety of Track :-

The POI is directly responsible for the safety of the track. He or she should be vigilant so as to promptly locate faults in the permanent way and get them repaired without delay.

The PWI also carries out following duties -

i) To check the proximity of tree that are likely to damage the track & get them removed.

ii) To check night patrolling at least once a month by train as well as by trolley.

iii) To take the necessary measures ensure execution maintenance work that affects the safety of the track.

iv) To rush to the site of an accident and take necessary measures to safeguard the line & restore traffic.

v) The witness the payments made out to the staff every month.

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Requirements of track drainage system:-

1- The surface & underground waters should be way away from a track.
2- The surface water from adjoining land should be prevented from entering the track formation.
3- Flow of surface water across the track along the slopes should not cause erosion of the banks & slopes of the embankment.
4- Sub-surface water should be efficiently drained off by the sub-surface drainage system.
5- In water logged areas, special precautions should be taken especially if detrimental salts are present or if floods are common in the area.

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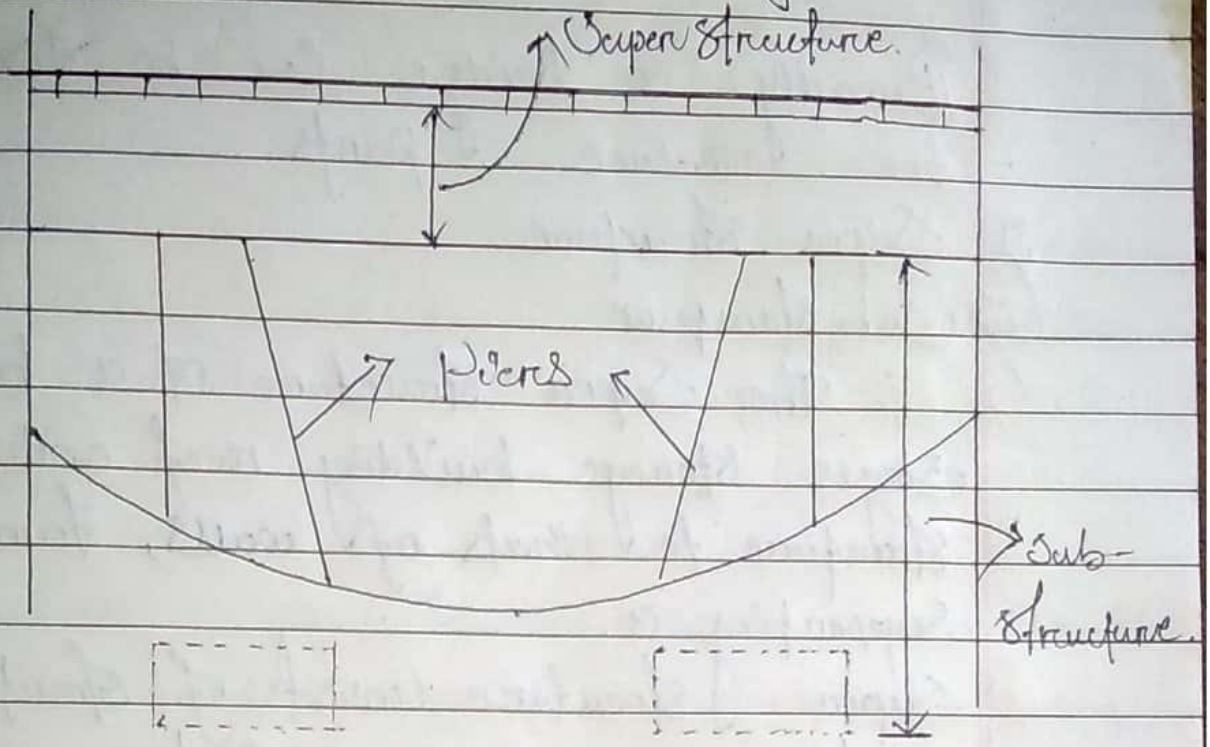
Bridge :-

Components Parts of a bridge :-



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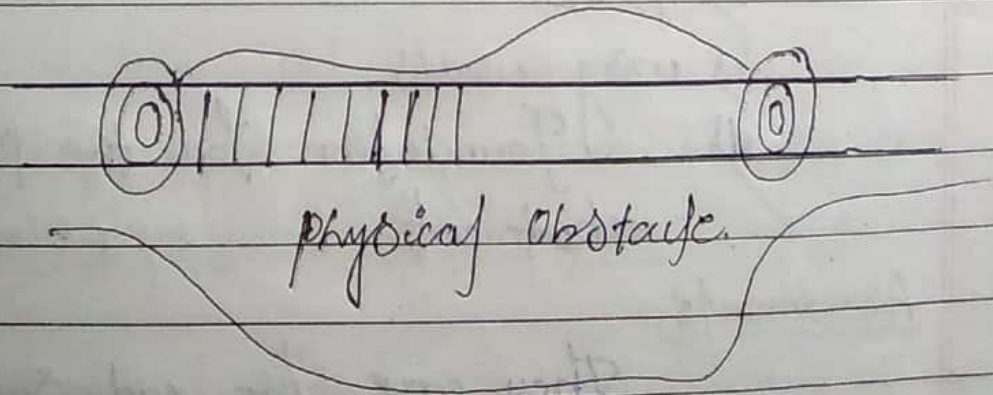
Bridge :-

Any structural form build to span the physical obstracles without disturbing the underside object.



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Components of a bridge:-

Broadly a bridge can be divided into two measure parts.

i) Super structure
ii) Sub-structure.

The Super structure of a bridge is a single storage building roof and Sub-structure to that of walls, foundation supporting it.

Super structure consists of structural members carry a communication route. Thus, hand rails, guard stone and flooring supported by structural system, such as beams, arches, conforms etc.

Sub-structure is supporting system for Super-structure.

It consists of:-

a) Abutments.
b) piers.
c) wing walls.
d) Foundation for the piers and abutments.

Abutments:-

They are the end support of the Superstructure.

Piers:-

They are the intermidiate support of a

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bridge super-structure and may be of solid or open type.

Effective Span:-

The centre to centre distance between any two adjacent supports is called effective span of a bridge.

Culvert:-

When a small stream crosses a road with linear waterway less than about 6m, the cross drainage structure so provided is called culvert.

Wing walls:-

wing walls are essentially retaining walls adjacent to the abutment.

Cantilever Bridge:-

Bridges which are more or less fixed end & free at the other. It can be used for spans varying from 8m to 20m.

Classification of Bridges:-

Material used for Construction -

Under this category, bridges may be classified as timber bridges, masonry bridges, steel bridges, RCC bridges, pre-stressed

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bridges and composite bridges,

① According to Alignment :-

↳ Straight bridge.

↳ Skew bridge.

② Location of bridge Floors :-

↳ Deck bridge :-

↳ whose flooring are supported at the top of the Superstructure.

↳ Semi-through bridge :-

whose floorings are supported at the some inter-mediate levels of Superstructure.

↳ Through bridges :-

whose floorings are supported or suspended at the bottom of the Superstructures.

Requirements Of an Ideal Bridges :-

i) It is economical.

ii) It is aesthetically Sound.

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ii) It serves the intended function with almost safety and convenience.

BRIDGE SITE INVESTIGATION AND PLANNING

Ideal Bridge Site Characteristics:-

i) It should be geologically suitable.
ii) The stream at the bridge site should be well defined as narrow as possible.
iii) There should be a straight reach of stream at bridge site.
iv) The site should have permanent, straight, & high banks.
v) The flow of water in the stream at the bridge site should be on steady condition.
vi) There should be no adverse environmental impact.
vii) The bridge should be such that adequate vertical height & water way is available under the bridge for navigational use.
viii) In case of curve alignment the bridge should not be on the curve but preferable at the tangent.
ix) In order to have minimum foundation cost, the bridge site should be such that

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no excessive work is to be carried out inside the water.

x) There should be no need for costly river training works in the vicinity of bridge site.

xi) In order to achieve economy there should be easy availability of labour, construction Materials & transport facility in the vicinity of bridge site.

* The various factors which should be carefully examined before setting forary upon the layout of a bridge are-

i) Geographical condition.

ii) Government Requirement.

iii) Foundation considerations.

iv) Stream characteristics.

v) Time consideration.

vi) Maintenance & Repairs.

vii) Construction facility available.

viii) General Features of the bridge structures.

ix) Environmental Impact.

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Bridge Hydrology:-

Determination Of Flood Discharge:-

↳ By the Empirical Formula.
↳ By the Rational Methods.

(1) By The Empirical Formula:-

Following are commonly used Empirical method for flood estimation in India.

In this method the area of a basin or a catchments is considered mainly.
A general equation may be written as-

$$Q = C.M^n$$

where,
Q = Rate of maximum discharge.
C = Constant for the catchment.
M = Area of the Catchment in Sq km.
n = An index.

i) Dicken's Formula:-

$$Q = C.M^{3/4}$$

where, M = Area of Catchment in km^2.
Q = Rate of max. discharge.

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c. According to the area of catchment and amount of rain 'c' varies from 11.02 - 22.04.

Region	Value of 'c'
Northen India.	11.37
Central India.	11.37 - 19.28
western India.	22.04

ii) Dyre's Formula:-

$$Q = C.M^{2/3}$$

Here,

C = 6.74 for area with in 24km from coast.
= 8.45 " " " " 24-161km " ".
= 10.1 " hilly area.

iii) Inglis Formula:-

a- For Small area only -

$$Q = 123.2\sqrt{M}$$

where, M = area of catchment in Sq.km.

b- For area between 160-1000Sq.km -

$$Q = 123.2\sqrt{M} - 2.62(M - 259).$$

c- For any types of Catchment area:-

$$Q = \frac{123.2M}{\sqrt{M + 10.36}}$$

(2) By the Rational Method:-

↳ This method is only applicable for culvert.

* Empirical bridge - Flood discharge.

The size of the flood depends on the following factors -

i) Climate & Rainfall factors.
   a) Intensity.
   b) Duration of Rainfall.
   c) Distribution.

ii) Catchment area factors.
   a) Catchment area.
   b) Porosity of soil.
   c) It's shape.
   d) It's slope.
   e) Initial state of wetness.

Waterway:-

waterway through which the water flows under a bridge superstructure is known as waterway Observe bridge.

Afflux:-

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Due to the construction of bridge there is a constraction in water way. This results in rise of water level above its normal level while passing under the bridge. This rise is known as afflux.

Economic Span :-

The span for which the total cost of bridge structure is minimum is known as economic span.

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Bridge Foundation

Selection of a good foundation:-

The selection of the formation for a particular site depends on the following consideration -

i) Nature of subsoil.
ii) Nature & extend of difficulties such as presence of build tree trunk side, boxes to be met with.
iii) Availability of equipment.

Foundation:-

A foundation is that part of the structure which is in direct contact with the ground. It transfer the load of the structure to the soil below.

Depending upon their nature & depth, foundation is classified into two categories i.e.,

i) open foundation or shallow foundation
ii) deep foundation.

Open Foundation:-

This is the most common type of foundation above the watertable. The base of the structure is enlarged

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are spread to provide individual support. Since spread foundation are constructed in open excavation, therefore they are called as open foundation.

The various types of spread footings are-

1- way footing.
2- Isolated footing.
3- Combined footing.
4 Inverted arch footing.
5- continuous footing.
6 - Cantilever footing.
7 - Grillage footing and
8- Stepped footing.

wall footing :-

These footing can be either 'simple or stepped'. The base of these footing can be of concrete or entirely of one material. Simple footing are used for eight structure. The base width of concrete base course shall be equal to twice the width of way. The depth of concrete bed is at least twice the projections. Generally, the projection provided on the footing is kept as 15 cm, on either side.

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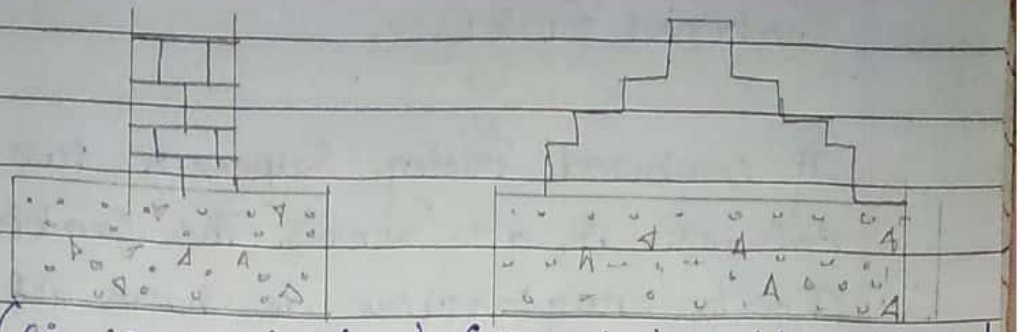
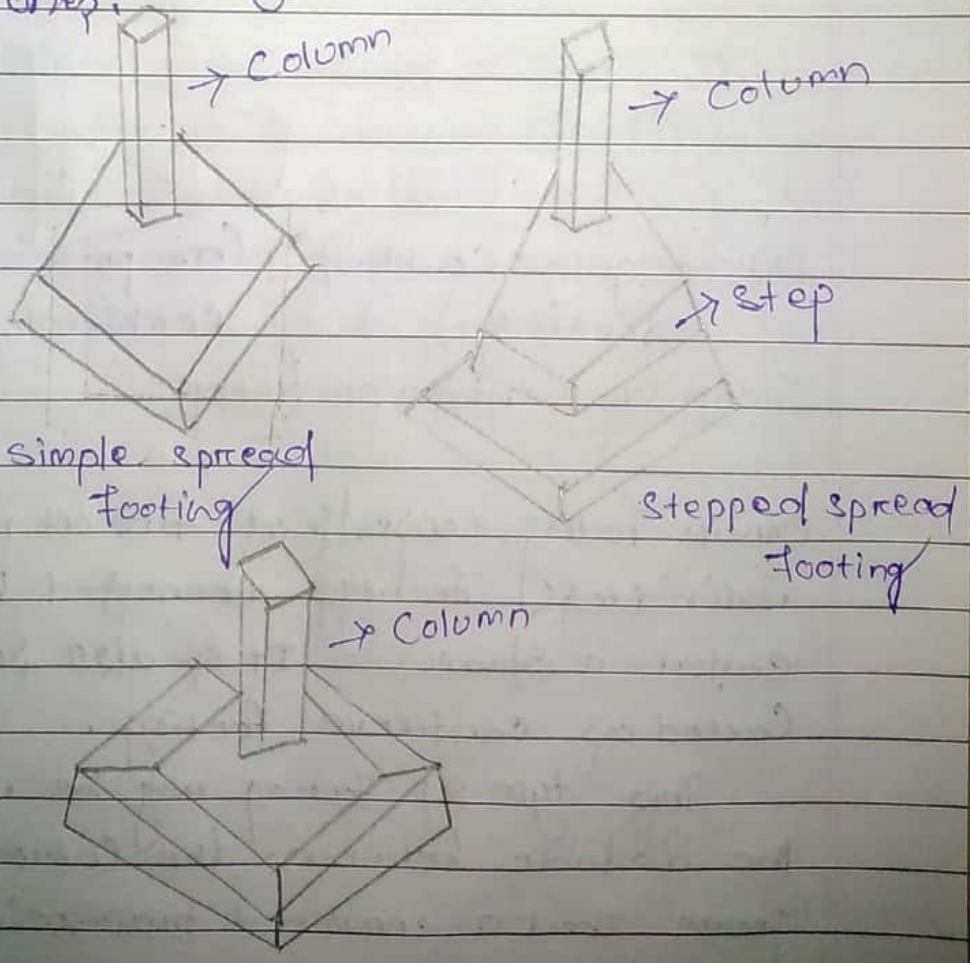


(Simple wall footing) (Two brick thick stepped wall footing)

Isolated or Column footing:-

They are used to support individual columns. They can be either of stepped type or have projections in the concrete base. The footing of concrete columns may be slab, stepped or sloped ones.



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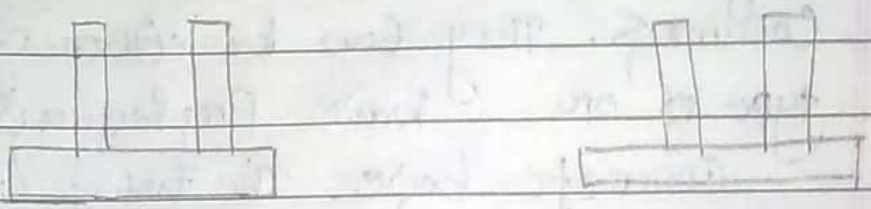
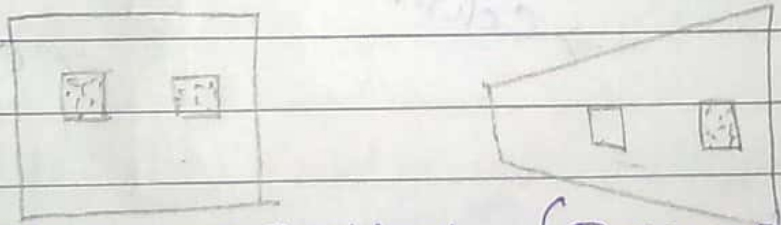
Combined footing :-

A combined footing supports two or more columns in a row. The combined footing can be rectangular in shape if both the columns carry equal loads or can be trapezoidal if there is space limitation and they carry unequal load.





(Rectangular Combined footing)

(Trapezoidal combined footing)

Strap or Cantilever footing :-

Strap footing consists of two or more individual footings connected by a beam called a strap. It is also sometimes called as cantilever footing.

This type of footing may be used where the distance between the columns is so great that a combined trapizoidal footing

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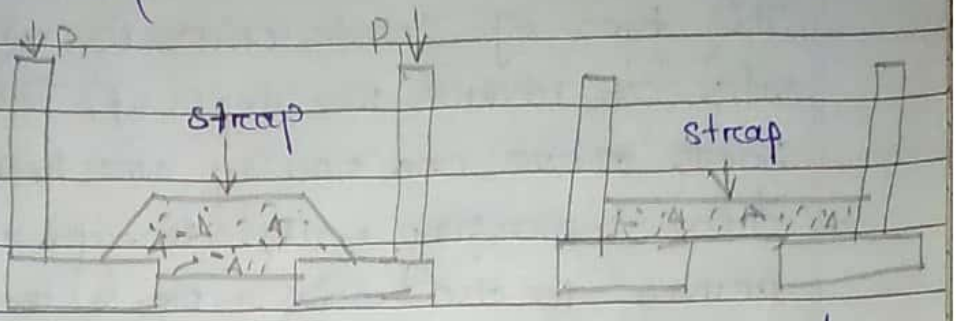
becomes quite narrow with high bending moments.

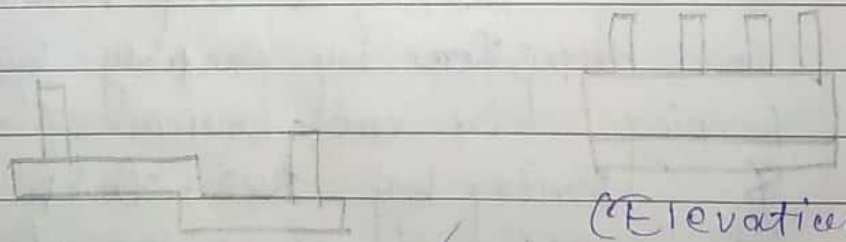


Strap footing with non-uniform strap

Cantilever footing with uniform strap

Continuous Footing:-

In this type of footing Single Continuous R.C. Slab is provided as foundation of two or more columns in a row. This type of footing is suitable at locations liable to earthquake activities. This also prevents differential Settlement in the structure.



(Elevation)

Stepped footing

(plan)

Strap foundation for closely spread Columns

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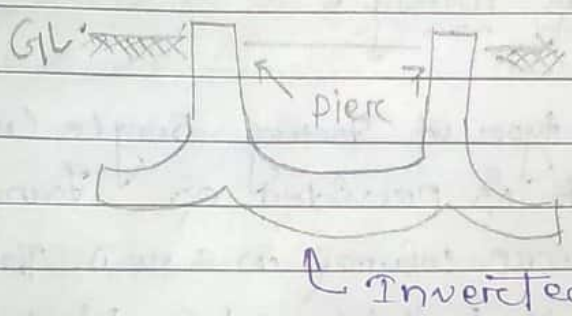
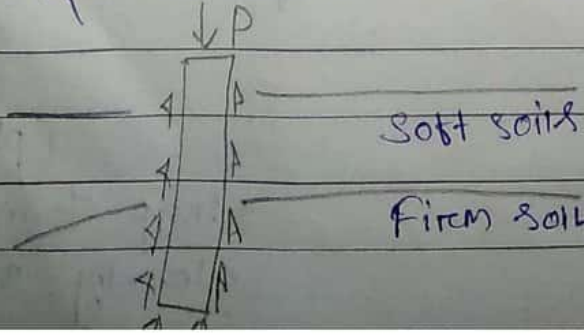
Inverted Arches :-

This type of construction is used on soft soils to reduce the depth of foundation. Loads above and opening are transmitted from supporting walls through inverted arches to the soils. In this type the end columns must be stable enough to resist the outward pressure caused by arch action.



Deep foundations :-

In this case of a deep foundation, the load transfer by partially by point bearing at the bottom of foundation & partly by skin friction with the soil around the foundation along its embedded in the soil.



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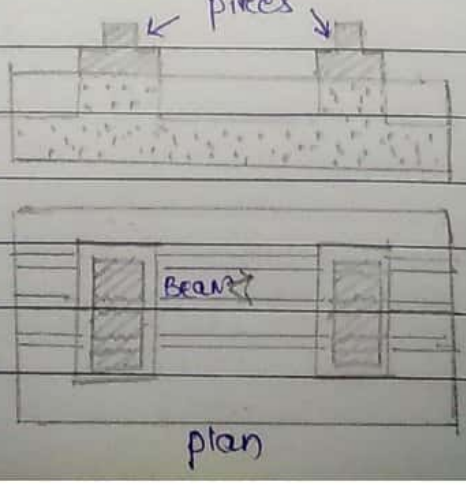
Raft Foundation:-

Raft foundation are used to spread load from a structure over a large area, normally, the entire area of the structure They are used where column loads or other structural loads are closed together & individual pads foundations would interact.

A raft foundation normally consists of a concrete slab which extends over the entire loaded area. It may be stiffened by ribs or beams incorporated into the foundation.

Raft foundation have like advantages of reducing differential settlements as the concrete slab resists differential movements between loading positions. They are often reduced in soft or loose soils with low bearing capacity as they can spread the load over a large area.



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Bridge Pier:-

A bridge pier is a type of structure that extend to the ground below or into the water. It is used to support bridge superstructure & transfer the loads to the foundation.

Bridge piers may be built using concrete, stone or metal. It is constructed in many locations like waterway, dry lands or which highways system are built as overpass.

Types of bridge piers:-

Based on the structure of piers, piers are categorized into two major types ① solid piers ② open piers.

1) Solid Piers:-

Solid piers possess solid & impermeable structure, & usually constructed from brick, stone masonary, mass concrete or reinforced concrete.

Solid piers are categorized into
↳ Solid masonary piers.
↳ Solid reinforced concrete piers.

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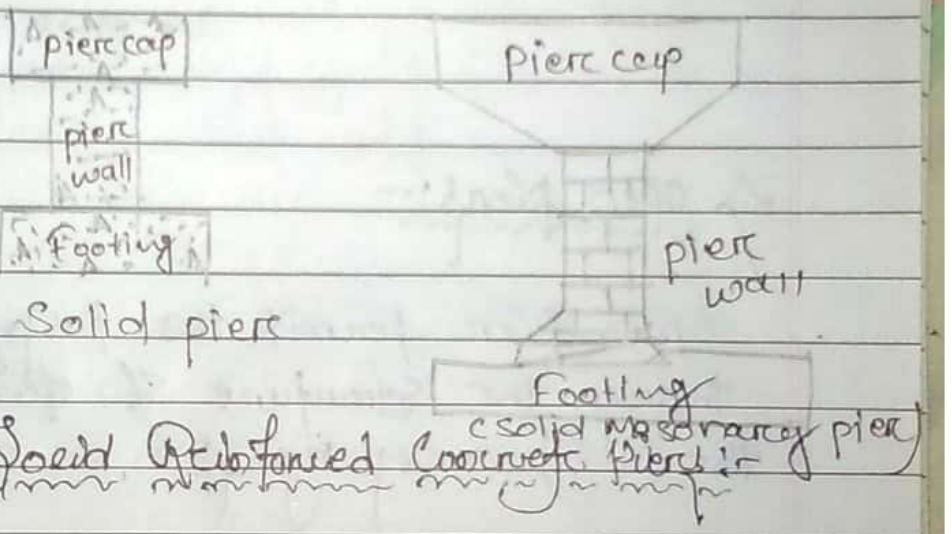
a) Solid masonry piers:-

It is constructed from brick masonry, stone masonry & concrete. For economic reasons, the outer part of solid masonry piers is built from stone masonry & the inner part is filled with the help of mass concrete.



b) Solid Reinforced Concrete Piers:-

Solid reinforced concrete piers are mostly constructed from reinforced concrete & normally rectangular in cross section. It is use in the case where the height of the piers is more & the solid masonry piers should not be strong enough to bear the load & can be uneconomical.

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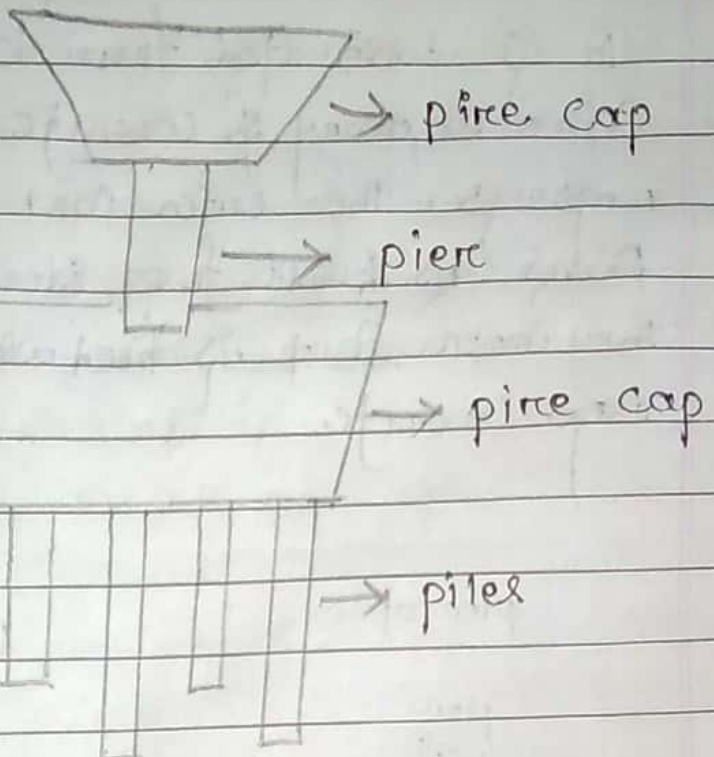

2) Open piers:-

Open piers permit the passage of water through the structure & classified into the following types:-

a) Cylindrical piers:-

Cylindrical pier is constructed from cast iron or mild steel cylinder which are filled with concrete. This type of pier is suitable for bridges with moderate height.

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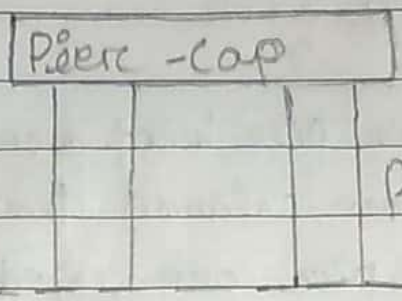


Elevation

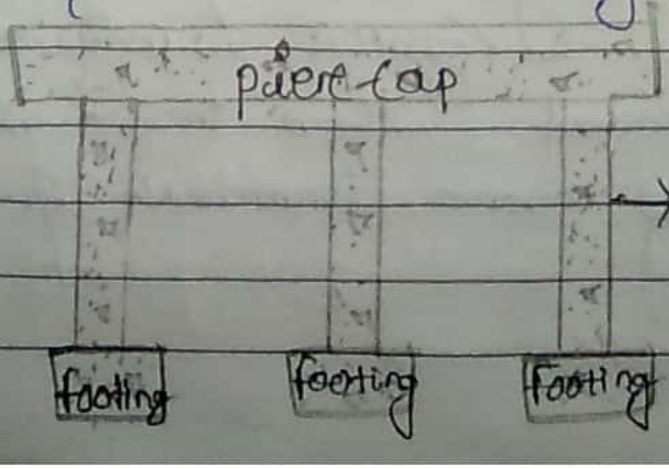
(plan)  Circular reinforced concrete shaft

b) Column piers or Column bents:-

This type of pier is suitable for bridge with significant height. It consists of a cap beam & supporting column forming a frame.

Column bents pier can either be used to support a steel girder superstructure or be used as an integral pier where the casting - place construction technique is used.

The column can be either circular or rectangular in cross-section. They are by far the most popular forms of piers in the modern highway system.



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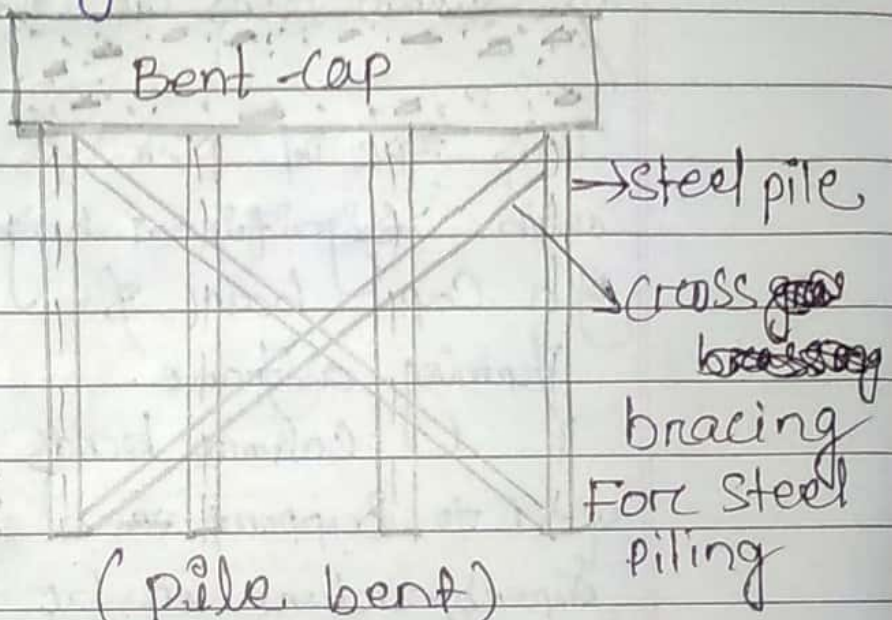
c) :- Pile Bent :-

Multi column or pile bent are composed of line or more columns that support cap. This type of pier are used, if the spacing between columns are large otherwise combined footing would be more suitable.



(pile bent)

d) Multiple bent or Multiple Column :-

They are often used on ground. The portion of wall at the bottom may or may not be used. It is needed for over pass where traffic runs parallel close to the bent to reduce damage to the columns in case of accident. It is lighten & may be more economical than the solid pile, but requires more formwork & excavation.

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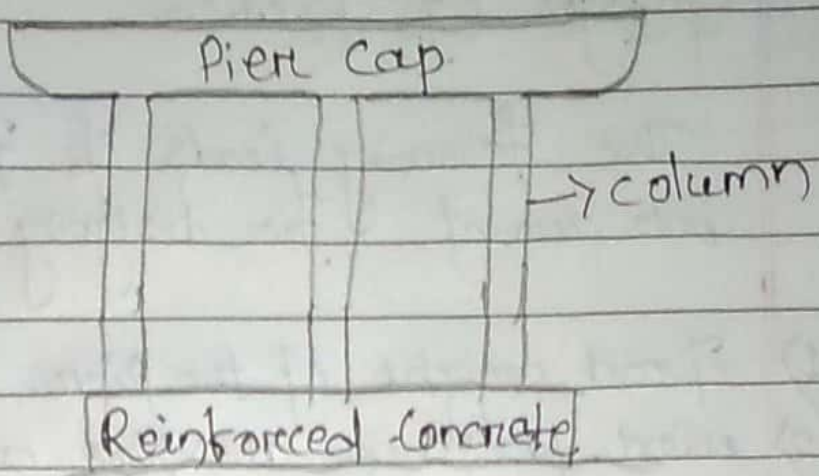
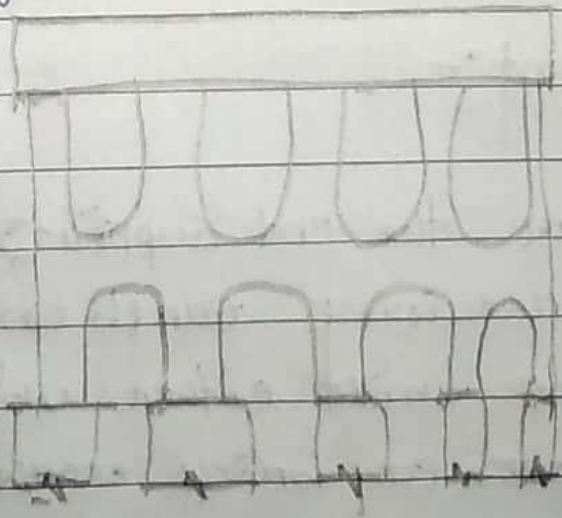


e) Trestle pier or Trestle bent:-

Trestle pier is composed of column with bend cap at the top. It is suitable for bridges in location where river bed is formed of which current is slow.



(pile Trestle)

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Design Of Pier:-

The following loads & forces are taken into account for designing a bridge pier.

1) Dead weight of the pier.
2) Wind Pressure acting on the Superstructure moving loads & the piers.
3) Water Pressure.
4) Earthquake forces in the event of bridge
5) Buoyancy effects of Submerged part of substructure.
6) End reactions due to live loads & dead loads of superstructure.
7) Centrifugal forces in the event of a road bridge situated on a curve.

Abutment:-

They are the end supports of the structure, retaining earth on their back. They are built either with masonary, stone, or brick work or ordinary mass concrete or reinforcement concrete. The top surface of the abutment is made flat where the superstructures is of trusses or girders or semi-circular arch.

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Abutments are classified under the following two categories.

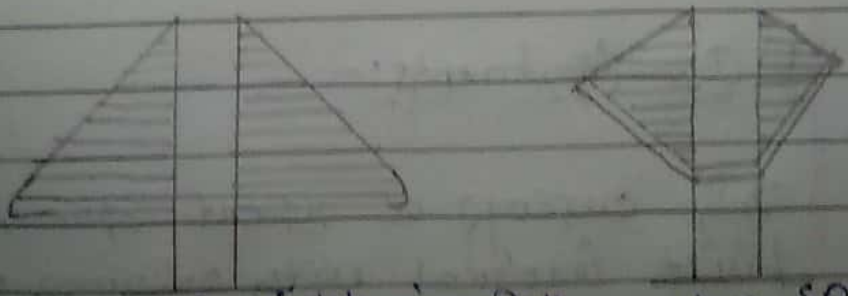
(1) Abutments with wing walls.
(2) Abutments without wing walls.

1- Abutments with wing walls :-

a) Straight wing walls.
b) Splayed wing walls.
c) Return wing walls.

In this type of abutment the wing walls can be either straight or splayed. The abutment using splayed wing walls are used across a river to provided smooth entry & exit for the water. The wing way not only withstand the earth pressure but also the impact of live load over them.

The abutments with return wing walls are known as U-abutments. In this type of abutment is extended at right angles on both the ends to some distance to protect the earth work.



plan straight wing wall plan splayed wing wall

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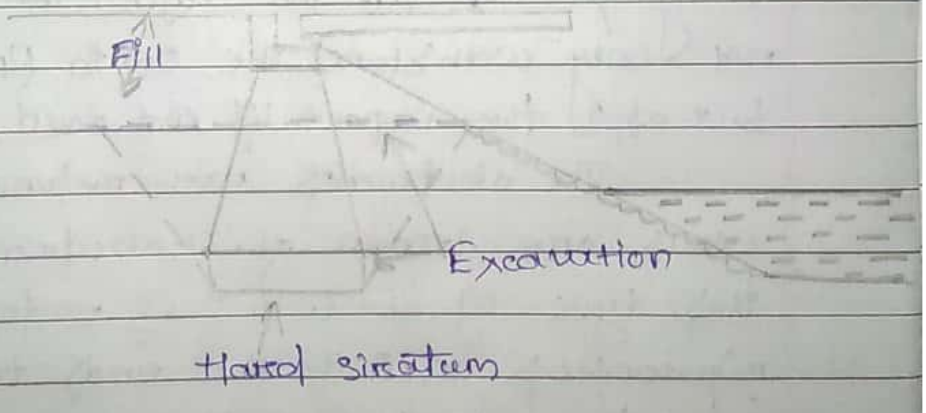
2- Abutments without wing walls :-

The following types of abutment are -

a) Buried abutments.
b) Box abutments.
c) Tee abutments.
d) Arch abutments.

a) Buried Abutments :-

This type of abutment is generally built prior to the placing of the fill. Since it is fixed on both sides the earth pressure is low.



b) Box Abutments :-

This employs a short span of bridge built integral with columns to act

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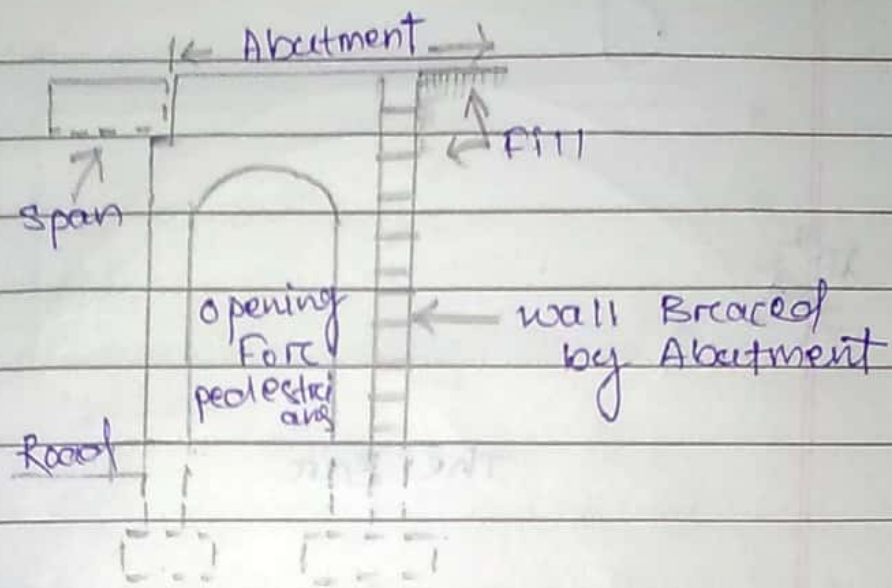
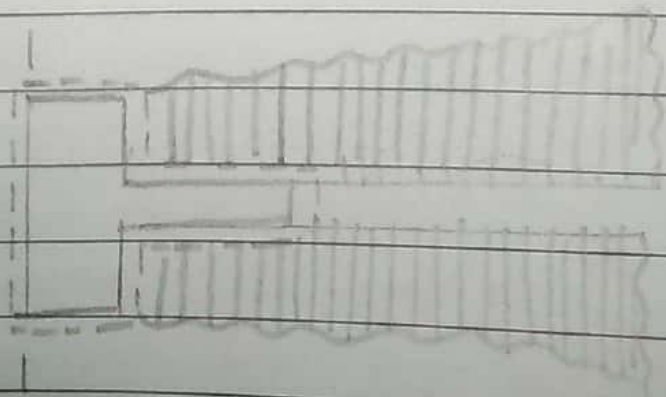
as a frame and resist earth pressure of the approaches. It is most often used for overpass work where the short span may be employed for pedestrain passage.



c) Tee Abutments :-

This type looks like T in plan & has now become obsolete.



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d) Arch Abutment :-

This types of abutment is used where arches are employed because of their economy in certain conditions.

Wing walls :-

These are the walls provided at both ends of the abutments to retain the earth filling of the approach road. They are constructed of the same material as those of the main abutment. The design of the wing wall depends upon the nature of banks. The wing walls are categorised as follows :-

1) Masonary wing walls.

2) Reinforced Concrete wing walls.

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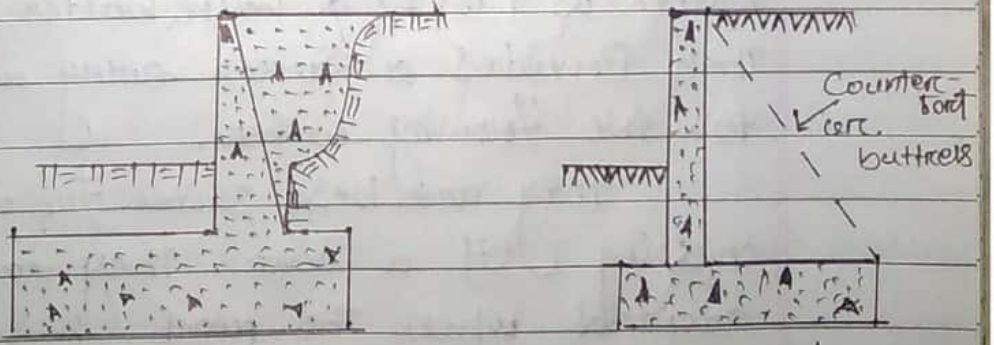
1) Masonary wing walls :-

The masonary wing walls either end abruptly or join a masonry return wall constructed parallel to the road-way with horizontal top. Their water face is kept either vertical or battered. Generally, the top of wing walls is either kept horizontal or sloping downwards.

2) Reinforced Concrete wing walls :-

Generally, Cantilever type or counterfort type retaining walls are used as the R.C.C. wing walls. The top of these wing walls is also either kept as horizontal or sloping downwards.



a. Cantilever Type b. counterfort type

As per their layout in plan, wing walls are classified as follows -

1) Straight wing walls. 3) Return wing walls.
2) Splayed wing walls.

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1- Straight wing walls :-

They are suitable for small bridges constructed across drains with low banks.

Generally they are built for a railway bridge specially in cities, where the cost of the land is high.

In case of hard and rocky foundation, the wing walls may be constructed in steps. When the soil is loose, the foundation should be taken to a uniform depth.

2- Splayed wing walls :-

They are constructed generally at 45° with abutment and are straight or curved in plan. Their top is 0.5m thick & their face batter is 1 in 12 & back batter is 1 in 6. They provides a smooth entry and exit to the flowing water.

They are best suited for the crossing of a river. They are also adopted when the road has to narrow on crossing the bridge, or when two or more roads meet at the approach.

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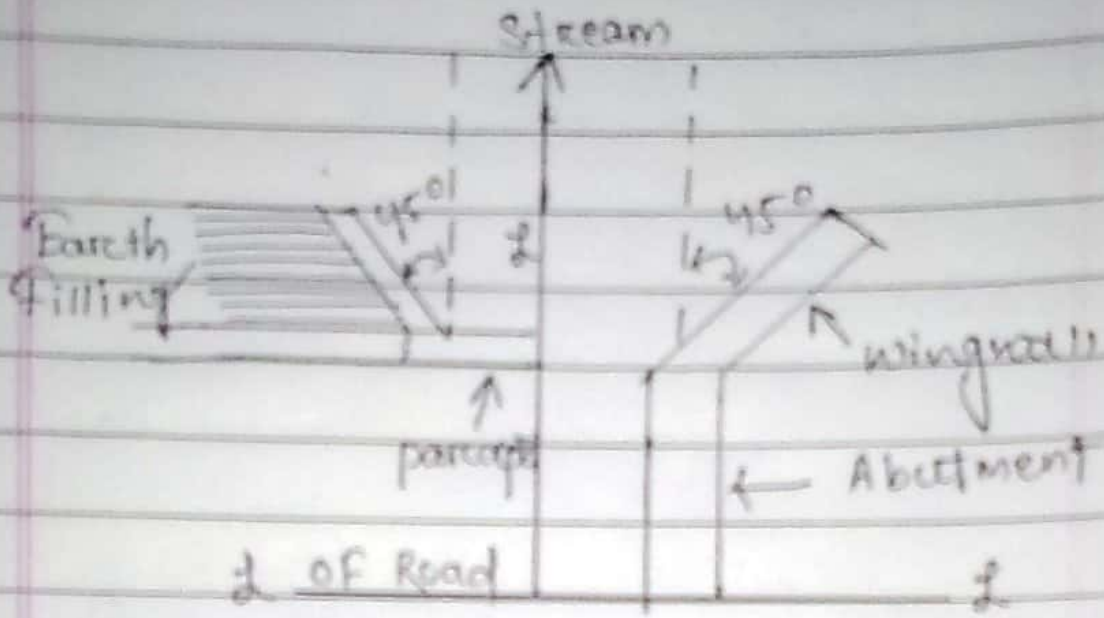

3- Return wing walls :-

These are walls built at right angles to the abutment at its both ends. They are designed to retain the earth filling of the approach road. Their top width is 1.5m, face is vertical and the back is given either a batter of 1 in 4 or stepping if the abutment has a stepped back.

They are suitable where the banks are high & rocky.

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(c) Tee Abutments

This type looks like T in plan & has now become obsolete.

Fig 10.3.5 (page : 410)

(d) Arch Abutments :- This type of abutment is used where arches are employed because of their economy in certain condition.

Fig 10.3.6 (page : 411)

APPROACHES

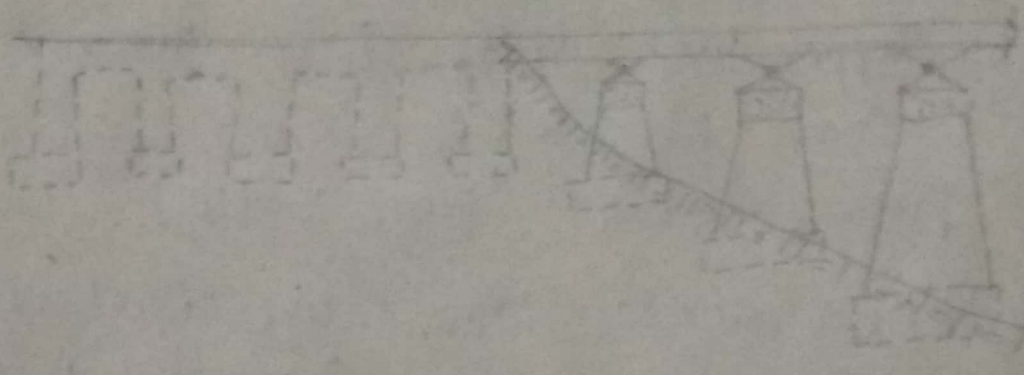
The approaches are the lengths of the communication route at both ends of the bridge.

Types

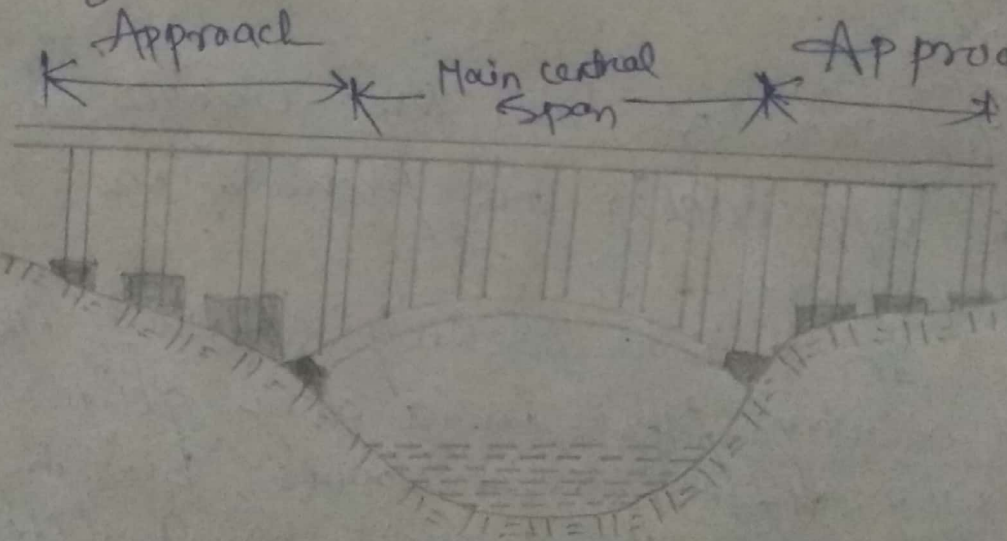
(1) In case of high level bridges & culverts the approaches are provided in embankment.

In a hilly & steep country, the river always flows in a deep gorge with well defined river banks, but in plains country, where the ground has a little slope, & the velocity is low, the flood water may spill over the banks. Therefore, in plains, the top of the approach should be kept above the highest flood level of the stream or river.

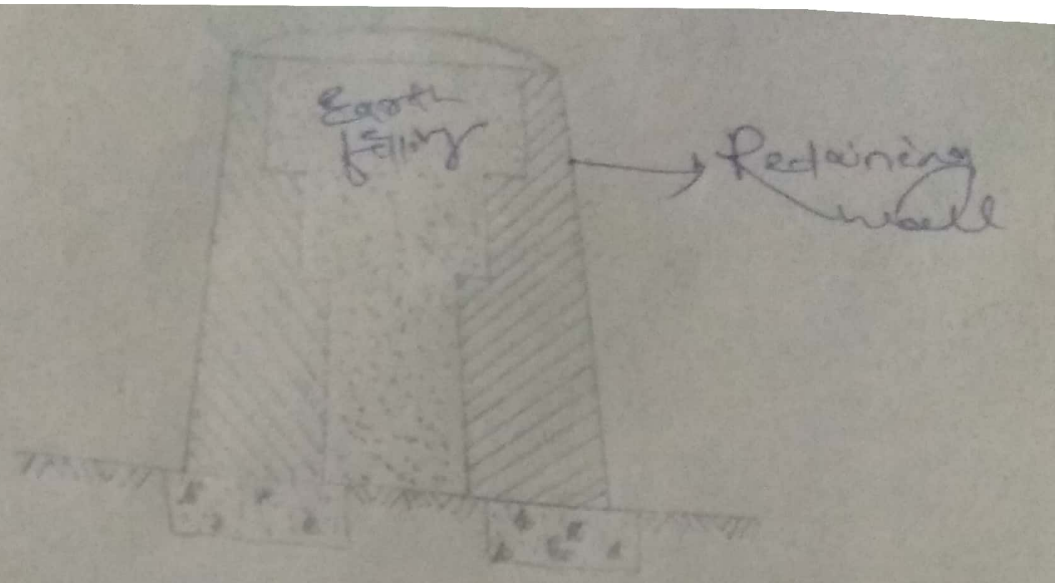
Sometimes the bridge is extended into the banks for some distance to provide better abutment structure to the approaches.



(2) In case of arch & suspension bridges, sometimes it is economical to cover only the central major portion of bridge. The approaches in such cases may be provided in the form of series of small spans from the banks to the main structure.



(3) In urban areas, where land is costly, the approaches are made of retaining walls constructed on either end of road width, & the earth work is filled in the middle.



CULVERT

A culvert is a small bridge carrying water under a roadway. It is used when the linear waterway does not exceed 12m. The waterway is provided in 1 to 3 spans, as required. In case of road culvert, span is limited to 5m & in case of railway, it is 6m.

The common types of culverts are

1. Arch culvert
2. Slab culvert
3. Pipe culvert
4. Box culvert.