Jai Ganesh
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SECTION-A: RAILWAYS (6th sem Civil Engg.)

(1)

Introduction:

→ It is the branch of engineering which deals with construction and maintance of railway tracks for safe and efficient movement of trains on it

→ The various modes of transport can be classified in the following ways -

(1) Classification from surface point of view -

(a) Land transport - Ex- Highways, Railways, Cable ways, ropeways etc.

(b) Water transport - Ex- Canal ways, River ways, Ocean ways, Lake ways etc.

(c) Air transport - Ex- Air ways

(2) Classification according to means of communication -

(a) Human porter
(b) Animal transport
(c) Road transport
(d) Rail transport
(e) Air transport
(f) Water transport
(g) Pipe line transport
(h) Conveyer transport
(i) Cable rope way transport

(3) Classification based on the freedom to move laterally and vertically -

(2)

(a) One degree of freedom :-

These modes in which vehicles are to free to move only along a line that is vehicles are vertically and laterally restrained.

Ex:- Railway, Pipeline, Conveyen system, Cable ways

(b) Two degree of freedom :-

These modes in which vehicles can move along a line as well as lateral i.e. vehicles as restrained only vertically

Ex:- Highway vehicles, ship boat.

(c) Three degree of freedom :-

These modes in which vehicles are free to move in any plane i.e. vehicles are neither lateral nor vertically restrained.

Ex:- Aeroplane, under water vehicle.

(4) Classification according to energy used for movement :-

(a) Human energy
(b) Animal energy
(c) Petrol and diesel energy
(d) Steam energy
(e) Solar energy
(f) Atomic energy
(g) Electric energy.

(3)

Characteristics of transportation mode :-

The transportation mode provide 2 basic utility —

(a) place utility :-

If having main and material at place where they are wanted

(b) Time utility :-

If having main material when they are wanted

Advantages of railways :-

(1) Political
(2) Social
(3) Economical

(1) Political Advantages :-

→ Railways have united the people of different cast religion and tradition.
→ With the adequate network of railways the central administration has become more easy and effective.
→ Railways have contributed towards development of national mentality in the minds of people.
→ The role of railway during emergency in mobilising troops and war equipment has been very significant.
→ Railways have help in the mass migration of the population.

(2) Social advantages :-

→ The feeling of isolation has been removed from the inhabitants of the Indian village.
→ By travelling together in the compartment without any restriction of cast, the feeling of cast difference has disappeared.
→ The social out look of the masses has been broaded through railway journey
→ Railways has made in easier to reach places of religious important.
→ Railways provided a convinient and shape mode of transport for the country.

(3) Economic Advantages :-

→ Mobility of people has increased there by the congested areas can be released of congection.
→ Mobility of labour has contributed to industrial development.
→ During famines railways have played the vital role in transporting food and clothing to the affected areas.
→ Growth of industries has been promoted due to transportation of raw materials through railways
→ Speedy distribution of finished product is achieved through railways
→ Railways provide employment to millions of people so that it helps in solving the unemployment problem of the country.

(5)

→ Main development due to railways thereby has increased the earning and standard of living of Indian people.

→ Land values have been increased due to industrial development which ultimately result in the increase of national wealth.

Techno economic advantages :-

→ Cost saving in transportation of long haul bulk traffic.

→ Energy efficient i.e. railways consume $\frac{1}{7}$th of fuel used by the road section

→ Environment friendlyness

→ Higher safety that is fatal accident one tenth of road section of Indian.

→ Efficient land used easy in capacity in expansion.

Classification of Indian Railways :-

Indian Railways lines are classified into 3 categories :-

(1) Trunk route.
(2) Main line
(3) Branch line

(1) Trunk route	Broad gauge	Meter gauge
(a) Max. permissible speed	120 Kmph	80 Kmph
(b) Rail section	52 kg/m	37.2 kg/m
(c) Sleeper density	N + 7	N + 7
(d) Ballast	25 cm below	20 cm below
(e) Degree of curvature	$7\frac{1}{2}^\circ$	Suitable
(f) Design speed	160 Kmph	100 Kmph

(b)

(2) Main line	Broad Gauge	Meter gauge
(a) max^m permissible speed	100 kmph	75 kmph
(b) Rail section	52 kg/m	37.2 kg/m
(c) Track relaying period	20 years	30 years
(d) Design speed	120 kmph	75 kmph

(3) Branch line	Broad Gauge	Meter gauge
(a) max^m permissible speed	less than 100 kmph	less than 75 kmph
(b) Rail section	52 kg/m	37.2 kg/m
(c) Track relaying period	20 years	30 years
(d) Design speed	120 kmph	75 kmph

Classification of Indian railway based on speed criteria :-

(a) Group 'A' line
(b) Group 'B' line
(c) Group 'C' line
(d) Group 'D' line
(e) Group 'E' line.

(a) Group 'A' line :-

It consist of those trunk route on which the trains are running at a speed of 160 kmph or more. Ex:- New Delhi to Howrah.

(b) Group B line :-

It consist of those route on which the trains are running with speed of 130 kmph.
Ex:- Ambala to Mughalsarai

(c) Group 'C' line :-

It consist of suburban of mumbai, Kolkata and Delhi

(d) Group 'D' line:-
All the routes in the country where max. permissible speed limit are present is 100 kmph.

(e) Group 'E' line:-
The other route and branch route where the permissible speed limit is >100 kmph.

Railway terminology:-

(1) Rails:-
Rails are steel girder over which the train moves and transmit the wheel load of the train to the sleeper below.

(2) Sleeper:-
Sleeper hold the rail in proper position and provide a correct gauge with the help of fitting and fastening.

(3) Ballast:-
Ballast holds the sleeper in position and provide a uniform level surface.

(4) Gauge:-
It is the clear distance betn the inner on running face of the railway track.

(5) Ballast Crib:-
The loose ballast betn the two adjacent sleeper is known as ballast crib.

(6) Boring:-
The process of filling the ballast around the

(6)
sleeper is called boxing on the ballast.

(7) Broad Gauge:-

The gauge of a track in which the distance between the running face of two track rails is 1.676 m is termed as broad gauge.

(8) Adhesion of wheel:-

It is resistance offered by the friction between metal surface of the rail and wheel

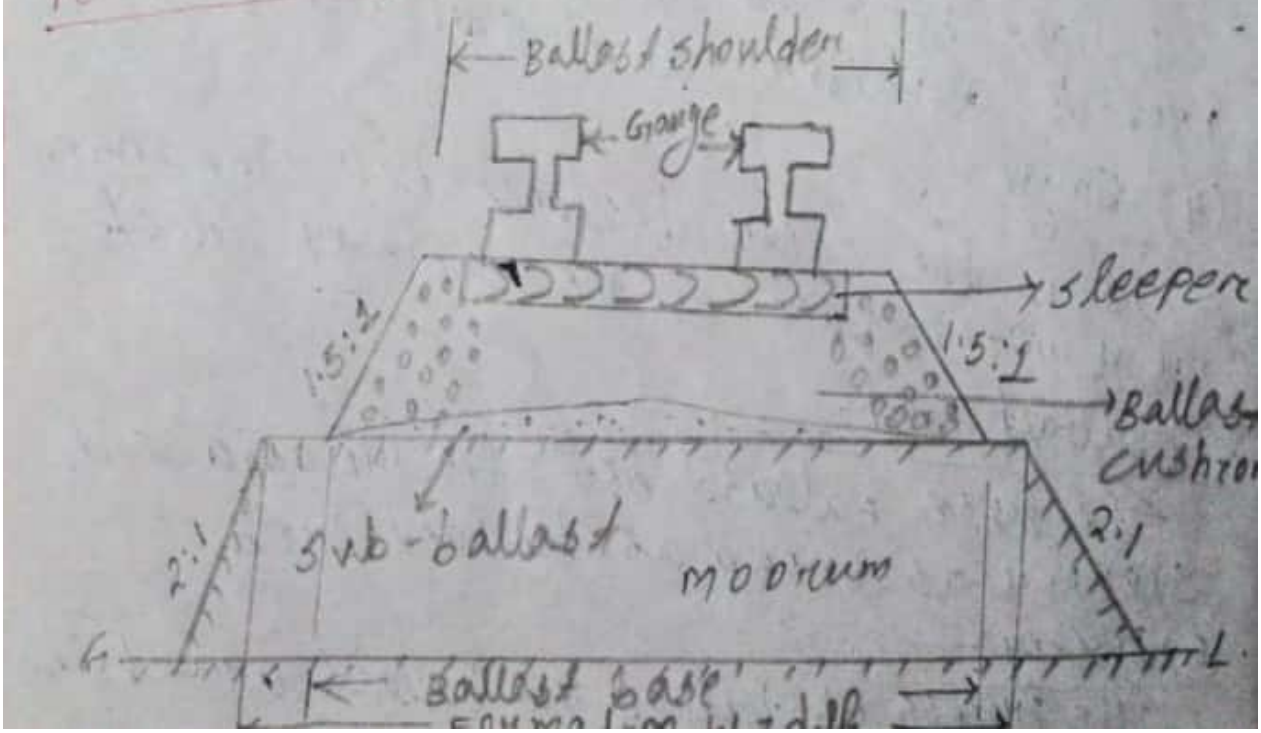
(9) Advance starter signal:-

It is the last stop signal semaphore type for an out going train.

(10) Audible signal or Fog signal:-

A container containing suitable explosive is put on the top of the rail so that there is explosion with a loud voice when wheels pass over the rails. This arrangement is called audible signal or Fog signal or a detonator.

Permanent way or railway track:-



(9)
→ The combination of rails fitted on sleeper and resting on ballast and subgrade is called the railway track or permanent way.
→ In permanent way the rails are join in series by fishplates and bolts and then they are fixed in sleeper by different type of fastening.
→ The sleepers properly spaced resting on ballast are suitably packed and bonded with ballast.
→ The rails act as girders to transmit the wheel load to the sleeper
→ The sleeper hold the rail in proper pos^n. w.r.t the proper tilt gauge and level and transmit the load from rail to the ballast.
→ The ballast distribute the load over the formation and holds the sleeper in proper pos^n.

Component of permanent way :-

(i) Rails
(ii) Sleeper
(iii) Ballast
(iv) Fitting and fastening.
(v) Formation
(vi) Gauge.

(i) Rails :-

Rails are steel girder over which the train moves and transmit the wheel load of the train to the sleeper below.

(ii) Sleeper :-

Sleeper hold the rail in proper position and provide a correct gauge with the help of fitting and fastening and transfer the train load to the ballast below.

(iii) Ballast :-

Ballast holds the sleeper in position and provide a uniform level surface. They also provide drainage to the track and transfer the train load to a larger area formation below.

(iv) Fitting and fastening :-

They provide a connection between rail and sleeper.

(v) Formation :-

→ It is the base of the track.
→ It gives a level surface where the ballast rest. It takes the total load of the track

(vi) Gauge :-

It is the clear distance bet. the inner on running face of the railway track.

Types of gauge :-

There are 4 types of gauge :-

(1) Standard Gauge
(2) Broad Gauge
(3) Meter gauge
(4) Narrow gauge

Gauge	Length
Standard gauge	1.435 meter
Broad gauge	1.676 meter
Meter gauge	1 meter
Narrow gauge	0.762 meter

Requirement of an Ideal permanent way:-

→ The gauge should be correct and uniform.
→ The rail should be proper level.
→ The alignment should be correct.
→ The gradient should be uniform and as gentle as possible.
→ The track should be resilient and elastic in order to absorb shock and vibration of running track.
→ The radii and superelevation of gauge should be proper design and maintained.
→ The drainage system must be perfect enhance safety and durability of track.
→ Joints including point and crossing which as regarded to be weakest point of the railway should be properly design and maintained.
→ There should be adequate provision for easy renewal and replacement.
→ The track structure should be strong low in initial cost as well as maintanance cost.

Capacity of a railway track:-

The track capacity of the increased by achiving faster movement of train on a track

by decreasing the distance betn. successive trains.

Suitability of gauge under different condition:-

There are some conditions on which gauge distance depends on they are:-

(1) Traffic consideration
(2) Physical features
(3) Development of areas.
(4) Cost of track
(5) Speed of train.

(1) Traffic consideration:-

→ Volume of traffic depends upon the size of wagon, speed and hauling capacity of train.

→ If the intensity of traffic is more broad gauge track is more acceptable.

(2) Physical features:-

→ On stipper gradient and sharp curve narrow gauge is provided.

→ In hilly areas narrow gauge is more reliable or useful.

(3) Development of areas:-

Narrow gauge is used to develop the thiny populated areas by joining the poor developed areas with urban areas.

(4) Cost of track:-
→ If sufficient funds are available then broad gauge track is adopted
→ In case sufficient funds are not available then narrow gauge is provided

(5) Speed of train:-
For greater gauge higher will be the speed and for higher speed broad gauge

TRACK MATERIAL

Rail:-
Rails are steel girders over which the train moves and transmit the wheel load of the train to the sleeper below.

Functions of rail:-
→ Rails provided a hard, smooth and unchanging surface for movement of train.
→ Rails bear the stresses developed due to heavy vertical load, lateral and ~~breaking~~ braking forces and thermal stresses.
→ The rail material used is such that it gives min^m wear and avoid replacement changes and failures of rails due to wear.
→ Rails transmit the load to sleeper and consequently reduce pressure on ballast and formation below.

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Composition of Rail Steel:-

(1) For ordinary Rail:-
- (a) Carbon = 0.55 to 0.65%.
- (b) Manganese = 0.65 to 0.9%.
- (c) Silicon = 0.05 to 0.3%.
- (d) Sulphur = 0.05% or below.
- (e) phosphorous = 0.06% or below.

(2) For rails on point and crossing:-
- (a) Carbon = 0.5 to 0.6%.
- (b) Manganese = 0.95 to 1.25%.
- (c) Silicon = 0.05 to 0.2%.
- (d) Sulphur = 0.06% or below
- (e) phosphorous = 0.06% or below.

Requirement of Rails:-

→ Rail should be proper composition of steel.
→ The vertical stiffness should be high enough to transmit the load to several sleepers situated below.
→ Rail should be capable of with standing lateral force.
→ The head must be sufficiently deep to allow for an adequate margin of vertical wear.
→ Web of rails should be sufficiently thick to bear the load coming on it.
→ Foot should be wide enough so that the rails are stable against overturning specially on curves.

→ The tensile strength of the rail piece should not be less than 72 kg/mm².
→ The rails specimen should withstand the blow of falling weight test on top test as specified by Indian railway standard without fracture.
→ Relative distribution of material of rail in head web and foot must be balanced for smooth transmission of loads.

Types of rail section:-

There are three types of rails:-
(1) Double headed rail (DH rail)
(2) Bull headed rail (BH rail)
(3) Flat footed rail (FF rail).

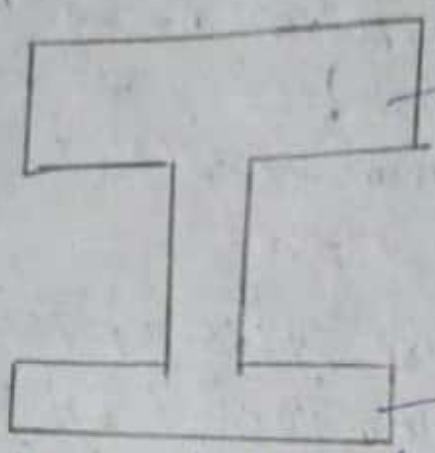
(1) Double headed rail (DH rail):-

→ Double headed rail or dumb bell originally dumb rail sections were designed in which both the heads were provided with the same cross-section.
→ The main object in designing such as section was that when the one top section had worn out due to moving wheels it could be inverted and reused lower section at the top but when such rails were practically used. it was found that due to impact of wheels the lower section became indentations and could not be used.

(Double headed rail)

(2) Bull headed rail:-

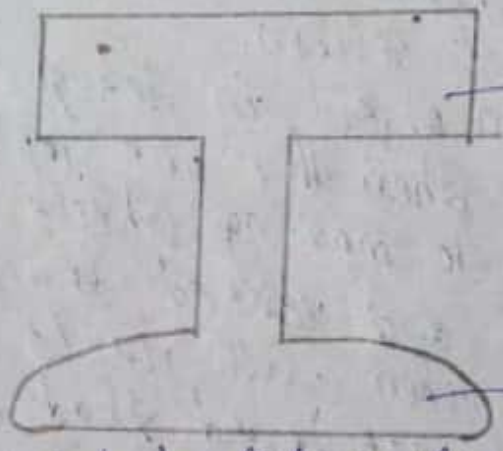
Bull headed rails in which the head was made little thicker and stronger than the lower part by adding more metal to it so that even after wear it can withstand stresses.



(Bull headed rail)

(3) Flat footed rail:-

Flat footed rails also called vignoles rail it was observe by heavy train load cause the foot of rails sink into the wooden sleepers.



(Flat footed rails)

(17)

Comparision between flat footed rail and Bull headed rail:-

Sl. No.	Points of comparision	F.F. rail	B.H or D.H rail
1.	Strength and stiffness	These have more strength and stiffness.	These have less strength and stiffness.
2.	Laying and Relaying	Fitting of these rails is simple. No chair is req^d.	The fitting of these rails is difficult and time consuming. Chair is required.
3.	Arrangement of point and crossing and sharp curve.	The arrangement are simple.	The arrangement are complicated.
4.	Alignment and stability of track.	In this impact of rolling wheel affect the fitting and the fitting disturbs the alignment and its place stability	The arrangement are complicated these rails when fitted on chair provide a more solid smooth track and better alignment.
5.	Initial cost.	This rails are req^d. cheaper fastening so the cost is less	These rails req^d. more and cost by fastening hence the cost is more.
6.	Maintainance cost	Maintainance cost is less.	It req^d. heavy maintainance cost.
7.	Inspection	Daily inspection is not necessary	In case of bull headed rail daily inspection of wooden is necessary.

Flat footed rails:-

Merits:-

→ They have more strength and stiffness both vertically and laterally than bull headed rail
→ Fitting of rails with sleeper is simple so they can be easily laid and relaid
→ No chair or keys are required.
→ In points and crossing the arrangement are simpler than bull headed rails.

Demerits:-

→ The fitting get loose more frequently than in case of bull headed rail the impact of rolling wheel directly affect the fitting
→ The straighting of bent rails replacing of rails and batten rails are difficult.

Bull headed rails:-

Merits:-

→ They keep better alignment and give more solid and smoother track.
→ The rails are easily disconnected from sleeper.
→ The heavy chairs with larger bearing on sleeper give longer life to wooden sleeper and greater stability to the track.

Demerits:-

→ They required additional cost of iron chair.
→ They have less strength and stiffness.
→ They required heavy maintance cost.

Length of Rails:-

→ As the weakest portion of the track is the rail joints, hence there are number should be as small as possible
→ To reduce the no of rail joints hence the length of rail should be increased but the length of rail is govern by the following factor:-
(a) Transportation facilities available.
(b) Manufacturing facility as well as economical cost.
(c) Loading, unloading, lifting and handling facility available.
→ During transportation and track laying keeping in view the above factor the following the standard length of rail are used in Indian railways.
FOR BG = 12.8 m long rail
MG = 11.8 m long rail

Rail joints:-

→ Rail joints are used to hold together the adjoining pt the rails in the correct position both in the horizontal and vertical planes.
→ Rail joints from the weakest part of the track.
→ It is absorbed that strength of a rail joint is only 50% of the strength of the rail.

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Requirement of an ideal joint.

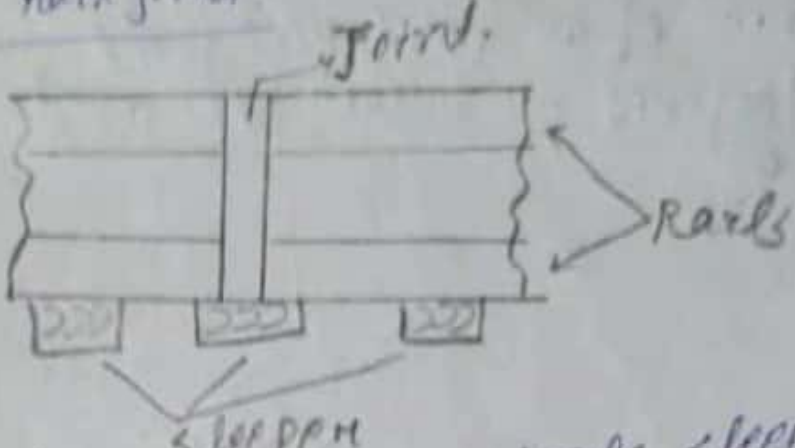
→ The two rail end should remain true in line both laterally and vertically when train is move on the track.
→ The rail joint should be as strength and stiff as the rail itself and should be elastic both laterally and horizontally.
→ The rail joint should provide enough space for free expansion and contraction to account for the effect of temperature variation.
→ A good joint should be easily disconnected so that it can be easily taken out without disturbing whole track for the purpose like change of rail or a fish plate.
→ It should not allow the rails ends to get battered.
→ The joint should fulfill the above requirement with the min^m. of initial and maintainance cost.

Types of rail joints:-

There are 10 types of rail joints:-
(1) Supported rail joints
(2) Suspended rail joints
(3) Bridge rail joints
(4) Welded rail joint.
(5) Staggered or broken rail joint
(6) Square or even rail joint.
(7) Compromise joint.
(8) Insulated joint.
(9) Base joint. (10) Expansion joint

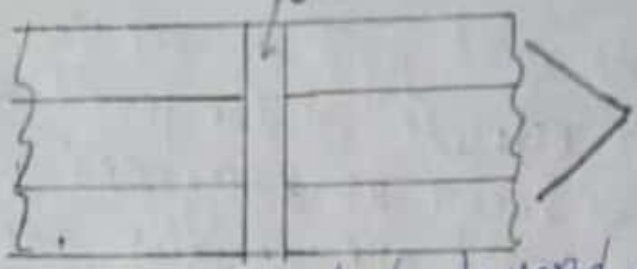
(21)

(1) Supported rail joint:-



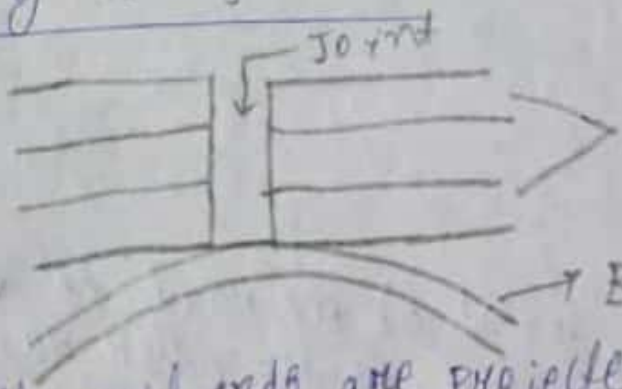
When the rail ends rest on a single sleepers is called a supported rail joints.

(2) Suspended rail joints:-



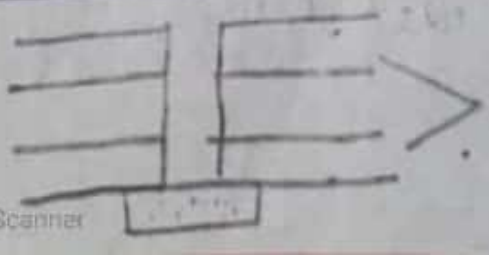
When the rail ends projected beyond sleepers is known as suspended rail joints.

(3) Bridge rail joint:-



When the rail ends are projected beyond the sleepers and they are carried by flat plane is known as bridge rail joint.

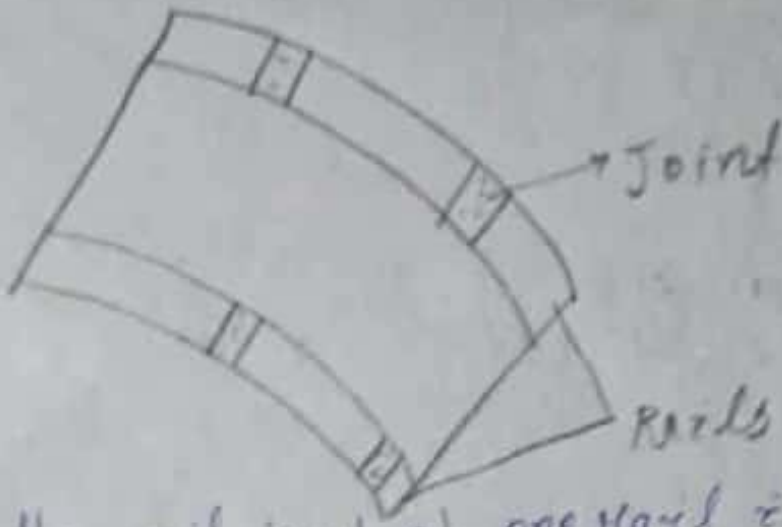
(4) Welded rail joint:-



(22)

It is a best joint as they fulfill all requirement of an ideal rail joint

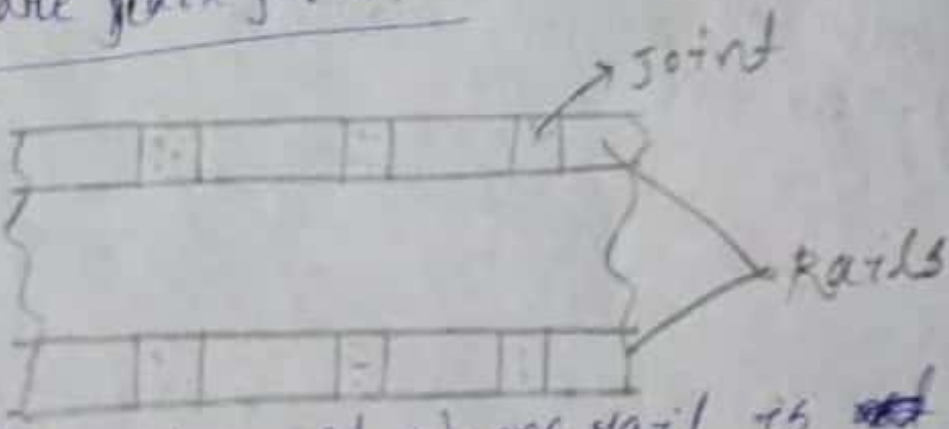
(5) Staggered or broken rail joint:-



→ When the rail joint of one rail is not directly opposite to the joint as the other rail is known as staggered joint

→ These joint are usually provided in curve

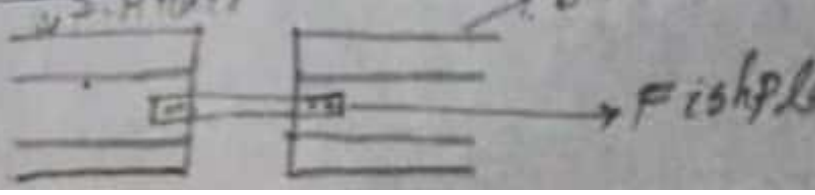
(6) Square rail joint:-



→ When the rail joint of one rail is ~~not~~ directly opposite to the joint as the other rail is known as ~~staggered joint~~ square joint

→ This type of joint is generally used in straight

(7) Compromise rail joint:-



(8) where the different rail section required to be joint together it is done by means of fishplate which fits both the rails this joint is known as compromised rail joint.

(8) Base joint:

This is similar to the bridge joint with the difference that the inner fishplate are of bar bar type and the outer fish plate are of the special angle type. Due to complicated design this is not generally used.

(9) Insulated joint:

When insulating medium is inserted in a rail joint to stop the flow of current beyond the track it is called insulated joint.

(10) Expansion joint:

→ In bridge provision for expansion and contraction is kept for girders and rails both.
→ This gap is 2.2 cm for welded joint and 2.7 cm for bolted joint

Purpose of welding:

→ To increase the length of the rail by joining two or more rail, so that the no. of joint and requirement of fishplate which load to economic and strength.
→ To repair the worn out or damaged rail so that increase their life.
→ To built up the burnt portion of rail head which is caused due to sleepage of wheel over the rail.

(24)

Advantages of welding rail:

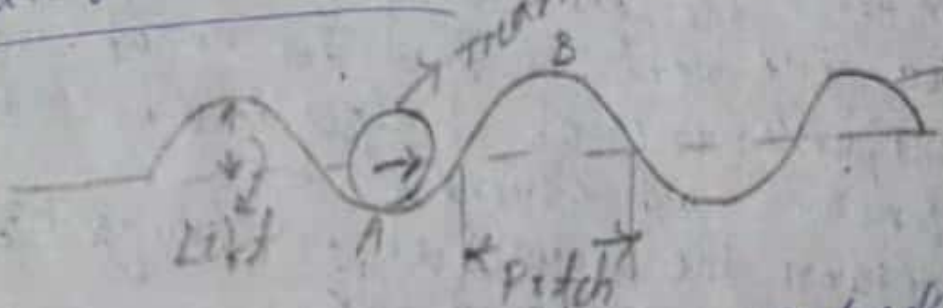
→ It is increase the life of the rail and also the induction in maintance cost by about 20 to 40%.
→ It reduce the creep due to increase in length of rail.
→ Expansion effect due to temperature is reduced so that it reduce the creep.
→ Long rail length being heavier damped the intensity of high frequency vibration due to moving load.
→ Welding increases the life of rail due to decrease in the wear of rail at joint.
→ The cost of track construction by welding of rail decrease due to less no. of rail joints.

Creep of rail:

Creep is the longitudinal movement of rail w.r.t sleepers in a track.

Causes of creep formation or Theories of creep:

(1) Wave action:-



→ Wave motion is set up by moving loads of wheels
→ The vertical reverse curve A, B, C is formed in the rails ahead of the wheels resulting from the rail deflection under the load is the cheap cause of creep the wheels push the wave with a tendency to pass the rail in the

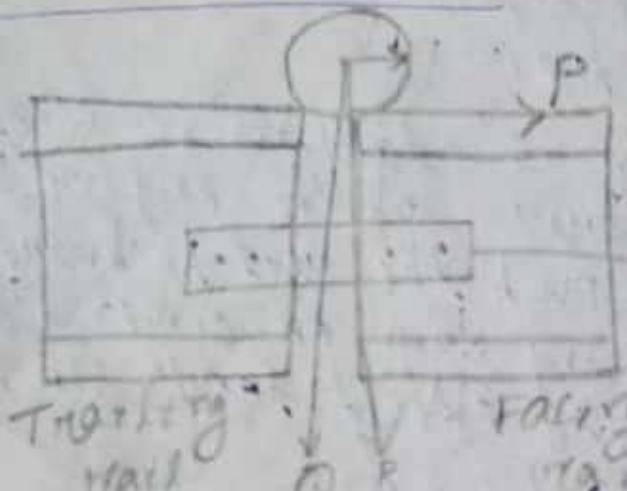
Direction of Creep:

→ On a particular rail the joint action by several wheel causes creep as the wheels move the first in front of the moving load is carried forward by the wheels and causes creep, whereas the first at the rear of the wheel gets back to its normal position.

→ The pitch and depth of wave depends upon the track modulus, stiffness of track, stability of formation.

→ The wave action can be reduced by angular and heavy ballast which develops good interlock increased stiffness of track, lessen sleeper spacing, bigger section of the rail.

(2) Percussion theory:-



→ This theory states that the creep is due to impact of wheels at the rail and ahead at joints.

→ The horizontal component P of R tends to cause creep while the vertical component tends to bend down the rail end vertically i.e. to make a batter rail.

→ When the wheel first the trailing rail and strike the facing rail end at each joint

it pushes the rail forward resulting in creep
→ the creep by this theory will increased due to quick and loose fish bolt, due to worn out fish plate, due to loose packing at joint due to wide expansion gap, due to heavy axial load moving at high speed.

(3) Drag or Dragging theory :-

→ It states that backward thrust on driving wheel of the locomotive of train has got a tendency to push the rail track backward while the other wheel of the locomotive and the vehicle push the rail in the direction of travel.
→ Wave action theory have greater effect than drag effect.

(4) Starting, acceleration, slowing down or stopping the train :-

→ When a train is starting or accelerating the backward thrust of the engine driving wheel tends to push the rail backward.
→ When it slowing down or coming to a stop the braking effect tends to push the rail forward.

(5) Expansion or contraction of the rail due to temperature :-

Creep also occur due to variation in temperature.

(6) Unbalanced traffic :-

In a single line system if heavy equal traffic runs in both direction the creep

is almost balanced otherwise heavy traffic in one direction will cause creep which is partly balanced by light traffic in opposite direction.

Effect of Creep:-

→ Sleepers move out of square and old of position.
→ Rail joints are often out of alignment in some cases and stresses are sets of in a fish plate and bolts due to which the bolts some time break.
→ Points and crossing get distorted and it becomes very difficult to keep them to correct gauge and alignment.
→ If any rail is removed from the track for any purpose from its become any difficult to fix it again at proper position because by the time gap becomes too short or too long due to creep.

Prevention of Creep:-

→ If the creep is not prevented it will result decrement.
→ Following are the common methods adopted to prevent creep.
(a) Fitting and fastening of sleepers.
(b) Use of proper size of ballast.
(c) Balanced traffic.
(d) Increase the weight of rail section.
(e) Regular maintenance of the rail.
(f) Welding of joint.

7) use of anticreepper
8) use of steel sleeper
9) sleeper

sleeper

→ sleeper holds the rails in proper position and provide a correct gauge with the help of fitting and fastening and transfer the train load to the ballast below.

Function of sleeper :-

→ TO hold the rail to correct gauge.
→ TO hold the rail in proper level.
→ TO act as elastic medium in bet^w the ballast and rails to observe the blows and vibration the moving load.
→ TO distribute the load from the rail to the under area of ballast.
→ TO support the rail at a proper level in straight track and at proper sleeper elevation on curve.
→ Sleeper also add to the longitudinal and lateral stability of the permanent track on the whole.
→ They also provide means to rectify track geometry during service life.

Requirement of sleeper :-

→ The sleeper should be used should be economical.
→ The fitting of the sleeper should be such that they can be easily adjusted during maintainance operation.
→ The weight of sleeper should not be too heavy or excessive that is they should have moderate weight for easy of handling.
→ The design of sleeper should be such that the cause alignment of track and levels of the rails can be easily adjusted and maintain.
→ The bearing area of sleeper below the rail seat

and over the ballast should be enough to resist the crossing due to rail seat and crossing of ballast below the sleeper. (29)

→ The sleeper design spacing should be such as a facilate easy removal and replacement of ballast.

→ The sleeper should be capable of resisting shock and vibration due to passage of heavy load of high speed train.

→ The design of the sleeper should be such that they are not damaged during packing prosses.

→ The design of sleeper should be such that they are not pushed out easily due to moving trains.

→ an ideal sleeper should also have an anti-savotadge and anti theaf qualities.

Types of Sleeper:-

1) Wooden sleeper.
2) Metal sleeper — cast iron sleeper, steel sleeper
3) Concrete sleeper — reinforced concrete sleeper, prestressed concrete sleeper.

1) Timber or wooden sleeper:-

→ Wooden sleeper are regarded to be best as they fulfill almost all the requirement of an ideal sleeper.

→ The life of timber sleeper depends open they are ability to resist wear decay attack by vermin and quality of the timber used.

Advantages

→ Timber is easily available in all parts of India.

→ Fitting of wooden sleeper are few and simple in design.

→ These sleepers are able to resist the shock and vibration due to heavy moving load and also give less noise to track.

→ woodens sleepers are easily lay, relay, pack, lift and

maintained.
→ These wooden sleepers are suitable for all types of ballast.
→ Wooden sleepers are economical.

Disadvantages:-

→ The sleepers are subjected to wear decay attached by white ants, warping, cracking and spliting, rail cutting etc.
→ It is difficult to maintain the gauge in case of wooden sleepers.
→ Track is easily disturb alignment maintainance is difficult.
→ wooden sleeper have got min^m service life i.e 12 to 15 years
→ maintainance cost of wooden sleeper is highest.

Metal sleeper

→ Due to going of scarcity of wooden sleeper their high cost and short life metal sleeper are now being widely adopted in india.
→ Metal sleeper are either of steel or cast iron. Cast iron is in greater use than steel for sleepers because it is less prone to corrosion.
→ Metal sleeper should satisfy the following requirement
* Metal sleeper should ~~beyond~~ bear the tensile or compressive stresses
* They should provide sufficient area for rail.
* Tamping and packing of ballast should not disturb the sleeper.
* For track circuiting insulation should be possible.
* Metal sleeper should be economical as compair to wooden sleeper.

Advantages:-

→ Metal sleeper are uniform in strength and durability.
→ In metal sleeper the performance of fitting is better and lesser creep occures.
→ Metal sleeper are economical as life is longer and maintainance is easier.
→ gauge can easily adjusted and maintain in case of

Metal sleeper.

→ For metal sleeper frequent renual is not required.

→ They have good scrap value is in manufacturing and not susceptable to fire hazard.

Disadvantages :-

→ More balallt is required then other tiype of sleeper.
→ Fittings required are greater in number and difficult to maintain and inspection.
→ Metals, cast iron or steel are liable to rusting.
→ Metal be good conductor of electricity interfease with track circuiting.
→ Metal sleepers are unsuitable for bridges, level crossing and point and crossing.
→ These sleeper are only suitable for stone ballast for rails for which they are manufactured

Cast iron sleeper :-

Advantages :-

→ They are easy to manufacture.
→ less corrosion.
→ Higher sharp value.
→ Less liable to crack at rail seats.

Disadvantages :-

→ providing less lateral stability.
→ gauge maintainance is very difficult.
→ More suspectible to breakage.

Steel sleeper :-

In india thousand of km of track has been laid using steel slee
These are the following requirement of steel sleeper.

i) The sleeper should maintain perfect gauge.
ii) It should be possible to fix the rate easily in the sleeper and without moving the sleeper longitudinally.

iii) The rail should have the sufficient bearing area on the sleeper.
iv) The sleeper should not be liable of being pushed easily out of position.
v) The metal of sleeper should be strong as enough as beam.
vi) They should be sufficiently heavy for stability.

Advantages :-
→ It is more durable.
→ It's service life about 50 years.
→ It is easy to maintain gauge and lesser maintainance problem.
→ It gives better lateral rigidity.
→ It is easy to manufacture.
→ It is not attack by vermine.
→ It is not suspectible to fire hazard.
→ It's scrap value is very good.

Disadvantages :-
→ It is liable to corrosion.
→ During service it's devlops crack at rail seat.
→ It requires more fitting than other.
→ More ballast is require than other type of sleeper.

Concrete sleeper :-
These sleeper are of two types
i) Rainforced concrete sleepers.
ii) pre-stressed concrete sleepers.

→ concrete sleeper made up a strong homogenious material, impervious to effect of moisture and is un affected by the chemical, attacked on atmospheric gases or subsoil salt.
→ It is moulded easily to size and shape required by scientific investigation to with stand the stresses produce by fast and heavy traffic.

Advantages :-

→ This sleepers are free from natural decay attacks by vermin, insects etc.

→ They have maxm life maxm 40 to 60 years.

→ This is not affected by moisture. Chemical action of ballast and sub soil salts.

→ Their is no difficulty in the track circuiting required for the electrifying the track.

→ The sleeper have higher elastic modulus and hence can withstand the stresses induced by first and heavy traffic.

→ Concrete sleeper in the elastic fastening offers and ideal track in respect of gauge, cross level and alignment.

Disadvantages :-

→ scrap value is negligible.

→ The damage to the Concrete sleeper is very heavy at the time of the derailment.

→ Bottom edge damage during packing

→ Handling of concrete sleeper is difficult due to heavy weight.

Pre-stressed concrete sleeper :-

→ In pre-stressed concrete sleeper the concrete is put under a very high initial compression.

Disadvantages :-

→ These are heavily damaged in case of derailment.

→ The bed of the ballast is specially prepared.

→ These are less economical.

→ The maintainance of the track is very high.

→ They are more rigid in nature.

Ballast :-

It is a layer of broken stone, gravel, Moorum Moorum of sand placed and packed below and around the sleeper for distributing

the load from the sleeper to the formation & for the providing drainage to the track.

Function of ballast :-

→ It transfer the load from the sleeper to the sub grade and them distribute it uniformly over a larger area of the formation.

→ To provide elasticity to track for getting proper riding comfort.

→ It holds the sleeper in position and prevent the lateral & longitudinal Movement due to dynamic load and vibration of moving train.

→ To provide good drainage to the track.

→ It provide effective means of maintaining evenness an alignment of the track.

Required of ballast

→ It should be tough.

→ It should not make the track dusty on muddy due to powder under dynamic wheel load.

→ It should be hard without getting thrust under the moving load.

→ It should be cubical having sharp edge.

→ It should be non porous & non-observent of water.

→ It should provide good drainage of water.

→ It should be durable.

→ It should not produce any chemical action with rail and Metal sleeper.

→ The size of stone ballast should be 5CM from wooden sleepers 4C.M for Metal sleeper 2.5 C.M of turned out and cross overs.

Material of Ballast :-

The diff^n materials are used as

i) Broken stone.

ii) Gravel or river pebbles or shingle.
iii) Ashes or cinders.
iv) Sand.
v) Moorum.
vi) Kankar.
vii) Brick ballast.
viii) Blast furnance slag.
ix) selected earth

i) Broken stone :-

→ This is the best material for the ballast and almost all important tracks are provide with stone ballast.

→ The based stone for ballast is non porous hard & angular which doesnot flay when broken.

→ workability is better with smaller size ballast that is 1.9 c.m size.

ii) Gravel or river pebble or shingle :-

It is ottend either from river beds or from gravel pits.

iii) Ashes or cinders :-

→ It has excellent drainage properly as it is very porous.

→ It is ~~chief~~ cheap. It is not use for main lines as it is very shoke. gets reduces to powdered under wheel load and makes the track very dusty.

→ It is excellent for station yards and for footpath.

iv) Sand :-

→ It is cheap and provides good drainage.

→ The gread drawbag of the sand of its blowing effect due to vibration.

→ The sand gets in to the moving parts on the track and causes heavy wear.

v) Moorum :-

→ It is the soft aggregate.

→ The based

→ It is used as a ballast for sliding and Naine track when they are newly laid and the embakement are not sufficiently consolidated.

→ when Moorum is finally laid on the track it forms a soiling or blanket under the stone ballast.

vi) Kankar :-

→ where stone is not easily available. It is used as road Metal and as ballast for railway track.

→ It is soft in nature and reduce the powdered under the loads.

→ It is used for narrow gauge or Metergauge track with light trafic. And where a better type of ballast is not available.

vii) Brick :-

→ where no stone or ~~suitable~~ substitute is available for use as ballast over burnt bricks are broken into small and used.

→ It's powders easily and produce adusty tracks.

→ It is ~~good~~ fairly good from drainage.

viii) Blast ferrace slag :-

→ It is a by product in the manufacture of the pig iron forms a suitable ballast material.

→ It should be hard of high density and free from cash holes.

ix) Selected earth :-

It is used in new formation as a temporary measure.

Packing :-

→ The process of ramming the ballast under the sleeper is known as packing.

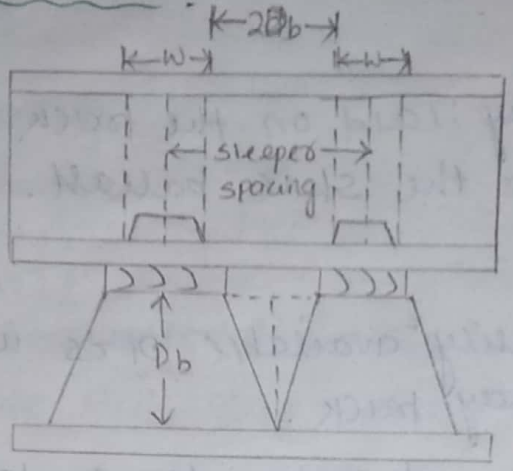
Boxing :-

The ballast above the packing layer which surrounds the sleeper is known as boxing.

Ballast crip :-

The loose ballast betwn the sleeper is known as ballast ~~creep~~ crip.

Depth of ballast section :-



$$S = 2D_b + \frac{W}{2} + \frac{W}{2}$$

$$= 2D_b + W$$

Depth of ballast $= S - W = 2D_b$

$$\Rightarrow D_b = \frac{S - W}{2}$$

Note

Depth of the ballast section will come betwn 20 to 25 C.M.

Q-1

Find the maximum depth of ballast cushion for a broad gauge track of wooden sleeper of having size (275 × 25 × 13) C.M width 75 C.M. sleeper spacing.

Ans

Length (L) = 275 C.M

Breadth (b) = 25 C.M.

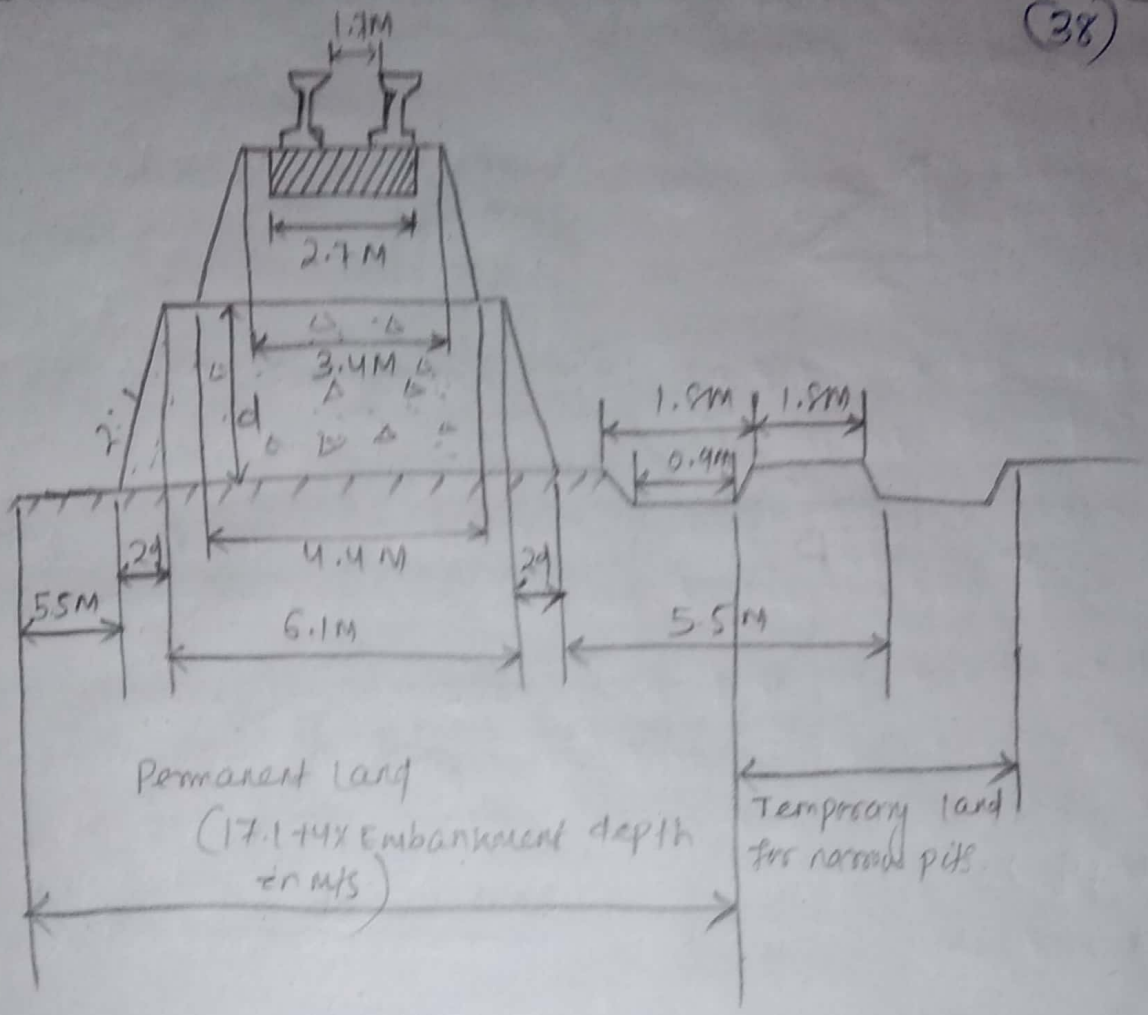
height (h) = 13 C.M.

Spacing (S) = 75 C.M

Soln

Depth of the ballast $(D_b) = \frac{75 - 25}{2} = 25$ C.M

The cross-section of B.G track in embankment on straight track.



— x —

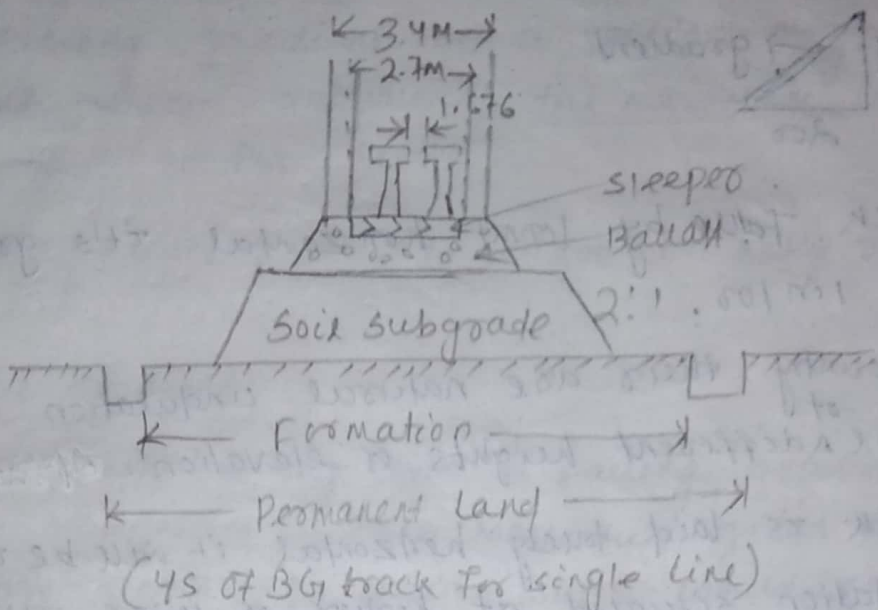
→ What is permanent way and write down the ~~para~~ component of permanent way.

→ Write down the different types of sleeper.

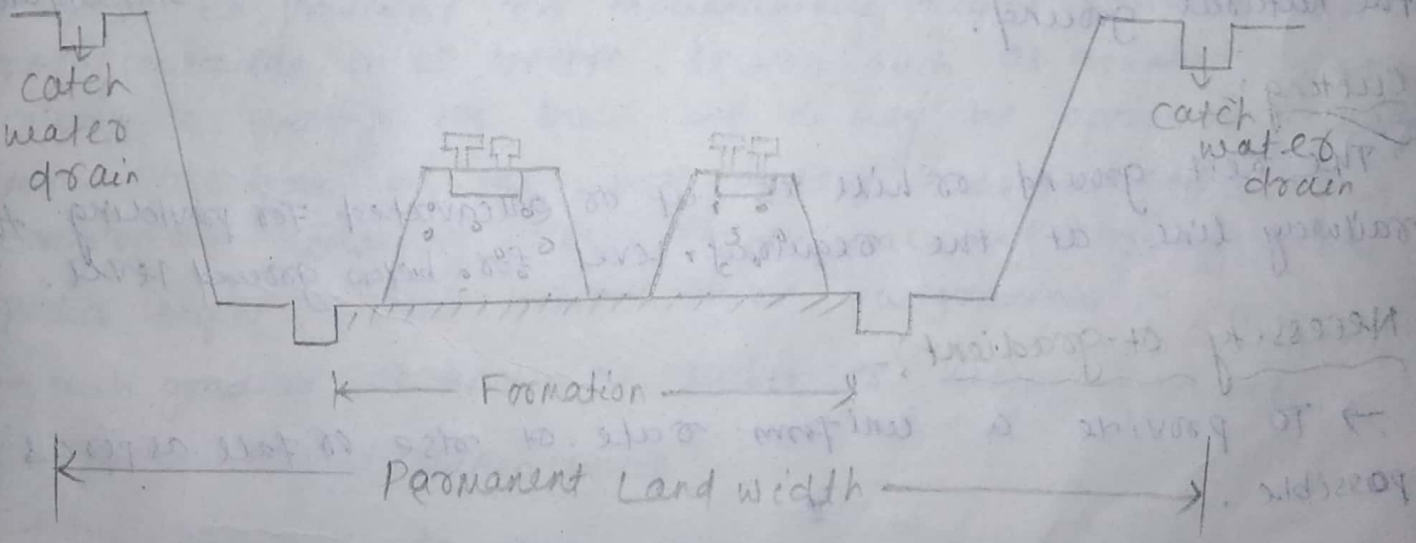
CHAPTER - 04

Dt - 27/01/2020

Geometric Design of Track



4s of BG track for double line

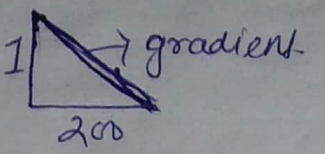


→ Most of the train derailment are due to the following reasons that is track deffect, vehicular deffect, operational deffect.

Gradient :-

→ The rate of riser or fall of the track is known as gradient.

→ It is expressed as the ratio of vertical to horizontal.
→ If the track rises 1M in 200M horizontal length it's gradient is expressed as 1 in 200



→ In the track falls by 100M horizontal it's gradient is expressed as 1 in 100.
→ In every country their are natural undulation and different places and are at different heights or elevation.
→ If the track is laid fully horizontal it will be impossible to reach other station situated at higher or lower altitude, therefore in order to reach diff^n station track are laid to sub-gradient.

Embankment:-

→ It is a rest bank of earth of other material constructed above the natural ground.

Cutting:-

The rest ground or hill is cut or excavated for providing the railway line at the required level for below ground level.

Necessity of gradient:-

→ TO provide a uniform rate of rise or fall as per as possible.
→ to reach the various station located at different elevation.
→ TO reduce the cost of earth work.

Types of gradient

Various gradient used on railway track can be classified as
1) Ruling gradient
2) Momentum gradient.

3) pusher or helper gradient.
4) Gradient at station yards.

1) Ruling gradient

→ The ruling gradient on a section may be defined as the gradient which determines the maximum load that the engine can haul on the section.

→ In plain terrain 1 in 150 to 1 in 200, in hilly reason 1 in 100 to 1 in 150.

2) Momentum gradient :-

→ A train while coming down a falling gradient acquires sufficient momentum. This momentum gives additional kinetic energy to the moving train which would enable to train to overcome a stipper rising gradient than the ruling gradient for a shutter length of the track this rising gradient is called as momentum gradient.

3) pusher or helper gradient :-

→ If is provided in mountainous region is the grade is concentrated in a specific section such as mountainous section instead of limiting the train load it may be operationally easy to run the train on the basic of load that the engine can carry on the remaining portion of the track and arrang for an pusher engine for the portion where the gradient is sevier.

→ such gradient as known as pusher or helper gradient.

4) Gradient at station yards :-

→ The gradients at station yards have to be sufficiently load due to the following reason.

i) To prevent the movement of standing vehicle on the track due to the effect of gravity combined with a strong wind or a gentle push.

ii) To prevent additional resistance due to grade on the static vehicle which is about to ice at the start that vehicle in motion.

→ On Indian railways for all gauges the max^{m} gradient permitted in station yards is 1 in 400 while a min^{m} gradient of 1 in 1000 is recommended from drainage point of view.

Grade compensation of curve:-

→ To avoid resistance beyound the allowable limits the gradients are reduced on curves and this reduction gradient is known as grade compensation for curve.

→ The curve resistance is expressed as a percentage per degree of the curve.

→ The curve resistance is greater at lower speed.

→ In India, compensation for curvature is even as 0.04% per degree of curve for BG, 0.03 percent for MG, 0.02 percentage NG.

→ Grade compensation $= \frac{75}{R}$ or $\frac{30+R}{R}$

Q-1

If the rulling gradient in 1 in 150 on a particular section of BG and at the same time a curve of 4° is situated on this rulling gradient what should be the allowable rulling gradient

Ans

Given data

As per IS recommendation, grade compensation for BG is 0.04% per degree of curve.

Compensation for 4° curve $= 0.04 \times 4 = 0.16\%$.

Rulling gradient $= 1$ in 150

$= \frac{1}{150} \times 100$

$= 0.67\%$.

Maximum allowable gradient $= 0.67 - 0.16 = 0.51\%$.

$= \frac{1}{\frac{100}{0.51}} = 196.07$

$= 1$ in 196

Q-2

what should be the actual ruling gradient if the ruling gradient in 1 in 200 on a BG and a curve of 3° is superimposer on a above track section of B.G.

Ans

Given data

As per IS recommended grade compensation for BG is 0.04% per degree of curve.

Compensation for 3° curve = $0.04 \times 3 = 0.12\%$.

Ruling gradient = 1 in 200

$= \frac{1}{200} \times 100$

$= 0.5\%$.

Maximum allowable gradient = $0.12 - 0.5 \equiv 0.38\%$.

$= \frac{\frac{1}{100}}{0.38} = 263.15$

$= 1$ in 263.15

Super elevation

→ TO counteract to effect of centrifugal force to level of the outer rail is raised above the inner edge by a certain amount to introduce the centripetal force. This raised elevation of outer rail above the inner rail at a horizontal curve is known as superelevation or cant.

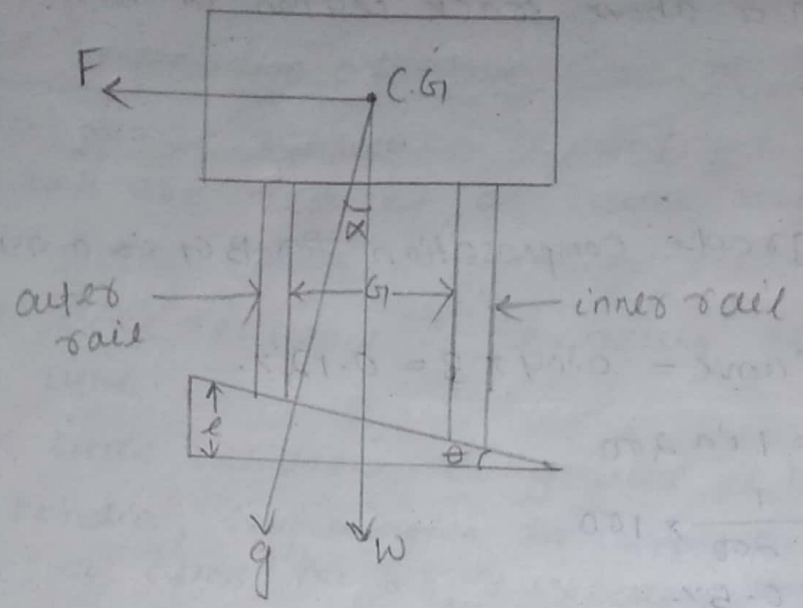
Object of providing superelevation :-

→ TO introduce the centripetal force for counter acting the effect of centrifugal force this will result in the faster movement of the train on curve. This will also prevent derailment and reduce the side wear and creep of rail.

→ TO provide equal distribution of wheel load on two rails so that their is no tendency of track to moveout of position due to more load on outer rail this reduce the ware of rail, equipment and results in saving its maintainance cost.

→ TO provide and even and smooth running track to ensure comfortable ride to passangers and save movements of goods.

Relation-ship of super elevation (e), gauge (G), speed (V), and Radius of the curve (R) :-



Where,

W = weight of moving vehicle in kg

V = speed of vehicle in kmph.

R = Radius of curve in meter.

G = gauge of track in meter.

g = acceleration due to gravity in M/sec^2.

α = Angle of inclination.

S = Length of inclined surface in meter.

Centrifugal force (F) $= \frac{Wv^2}{gR}$

$$\tan\theta = \frac{e}{G}$$

$$\tan\theta = \frac{F}{W}$$

$$\Rightarrow \frac{e}{G} = \frac{F}{W}$$

$$e = \frac{F}{W} \cdot G$$

$$e = \frac{\frac{Wv^2}{gR}}{W} \times G$$

$e = \frac{GV^2}{gR}$

→ V is in KMph $\frac{(0.278V)^2 \times G}{9.81 \times R}$

→ $e = \frac{GV^2}{127R}$ in M

→ $e = \frac{GV^2}{1.27R}$ in C.M

of BG

→ Super elevation $e = \frac{GV^2}{gR}$

$e = \frac{1.676V^2}{127R}$

$e = \frac{0.013V^2}{R}$ in M

$e = 1.3C.M$

→ Super elevation of MG.

$e = \frac{GV^2}{gR}$

$e = \frac{1 \times V^2}{127R}$

$e = \frac{0.007V^2}{R}$ in M.

$e = 0.7C.M$

→ Super elevation NG

$e = \frac{GV^2}{gR}$

$e = \frac{0.0762V^2}{127 \times R}$

$e = \frac{0.006V^2}{R}$ in M

$e = 0.6C.M$

Limits of super elevation :-

→ Normally the Maxm value of superelevation according to the railway board is 1/10th gauge. Therefore the maxm permissible value in india for different gauge are

i) Maximum superelevation for BG = $\frac{1}{10} \times 1.676 = 0.1676$ M
= 16.76 C.M

ii) Maximum superelevation for MG = $\frac{1}{10} \times 1 = 0.1$ M = 10M.

iii) Maximum superelevation for NG = $\frac{1}{10} \times 0.762 = 0.762$ M
= 7.62 C.M

→ Cant defficiency provided should minimum as possible as due to following reason,

i) Higher cant defficiency discomfort to the passanger.
ii) Higher cant defficiency result in unbalanced of centrifugal force.
iii) sight wear and creep of rail is more when defficiency is more.

$C_d = e$ – Actual Cant.

Negative cant or cant excess :-

→ It is difference betwn actual cant provided and theoriticaly cant requires for such lower speed.

→ It occures when train moving on the track with lower speed than it design speed.

Limits of cant defficiency :-

Gauge	cant defficiency for speed up to 100kmph	cant defficiency > 100 kmph
BG	7.6 C.M	10 C.M
MG	5.1 C.M	Not specified
NG	3.8 C.M	Not specified.

1) If a 8° curve track diverse from a main curve 5° in an opposite direction in the layout of a B.G yard calculate the superelevation and the speed on the branch line. If the maxm speed permitted on the main line 45kmph. (4M)

Given data

V = 45kmph.

Degree of curvature = 5°

G = 1.676M.

$D = \frac{1720}{R}$

$R = \frac{1720}{D}$

Soln

$e = \frac{1.676 \times V^2}{1.27 \times R}$

$R = \frac{1720}{5} = 344$

$e = \frac{1.676 \times 45^2}{1.27 \times 344}$

$= 7.76$ C.M

cant defficiency for BG = 7.6 C.M.

Cant for main track for 7.76 − 7.6 = 0.16 C.M.

cant to be provided for main track = 0.16 C.M

cant to be provided for Branch track = −0.16 C.M

cant defficiency of 7.6 CM which is permissible the speed of the train will be a cant

7.6 − 0.16 = 7.44 C.M.

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

$\Rightarrow 7.44 = \frac{1.676 \times V^2}{1.27 \times 215}$

$\Rightarrow V = 34.8 \text{kmph}$.

This is theoritical speed on branch line because the maxm speed on branch line should not be more than 34kmph.

Q-2

A 5° curve diverse from a 3° main curve in reverse direction in the layout of a BG yard if the speed on the branch line restricted 35 kmph determine the restricted speed on the Main line.

Given data

$V = 35$ kmph

Degree of curvature $= 5°$

$G = 1.676$ M.

$D = \frac{1720}{R}$, $R = \frac{1720}{D}$

$R = \frac{1720°}{5°}$

$= 344$

Sol^n

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

$e = \frac{1.676 \times 35^2}{1.27 \times 344}$

$e = 4.69$ C.M

cant defficiency of BG = 7.6 C.M.

cant for main track for 4.69 − 7.6 = −2.91 C.M.

cant to be provided for branch track = 2.91 C.M

cant deficiency of 7.6 which is permissible the speed of the train will be for a cant 7.6 + 2.91 = 10.51 C.M.

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

$$\Rightarrow 10.51 = \frac{1.676 \times V^2}{1.27 \times \frac{1720}{3}}$$

$$\Rightarrow V = 67.57 \text{ kmph}$$

So the restricted speed on main track, 67.57 kmph or 65 kmph.

Q-3

A 9° Branch curve diverse out from a 8° main curve in the opposite direction in MG yard in lay out if the speed restricted in 25 kmph for main line for cant defficiency permissible is 5.1 C.M what would be the speed limit of the branch line.

Ans

Given data

$V = 25$ kmph

Degree of curvature (D) = 8°

M.G = 1M

$$D = \frac{1720}{R}, \quad R = \frac{1720}{D}, \quad R = \frac{1720^0}{8} = 215$$

Soln

$$e = \frac{GV^2}{127R}$$

$$e = \frac{1 \times 25^2}{1.27 \times 215}$$

$$e = 2.28 \text{ C.M}$$

Cant defficiency of MG = 5.1 C.M

Cant for main track = 2.28 − 5.1 = −2.82 C.M

Cant to be provided for main track = 2.82 C.M.

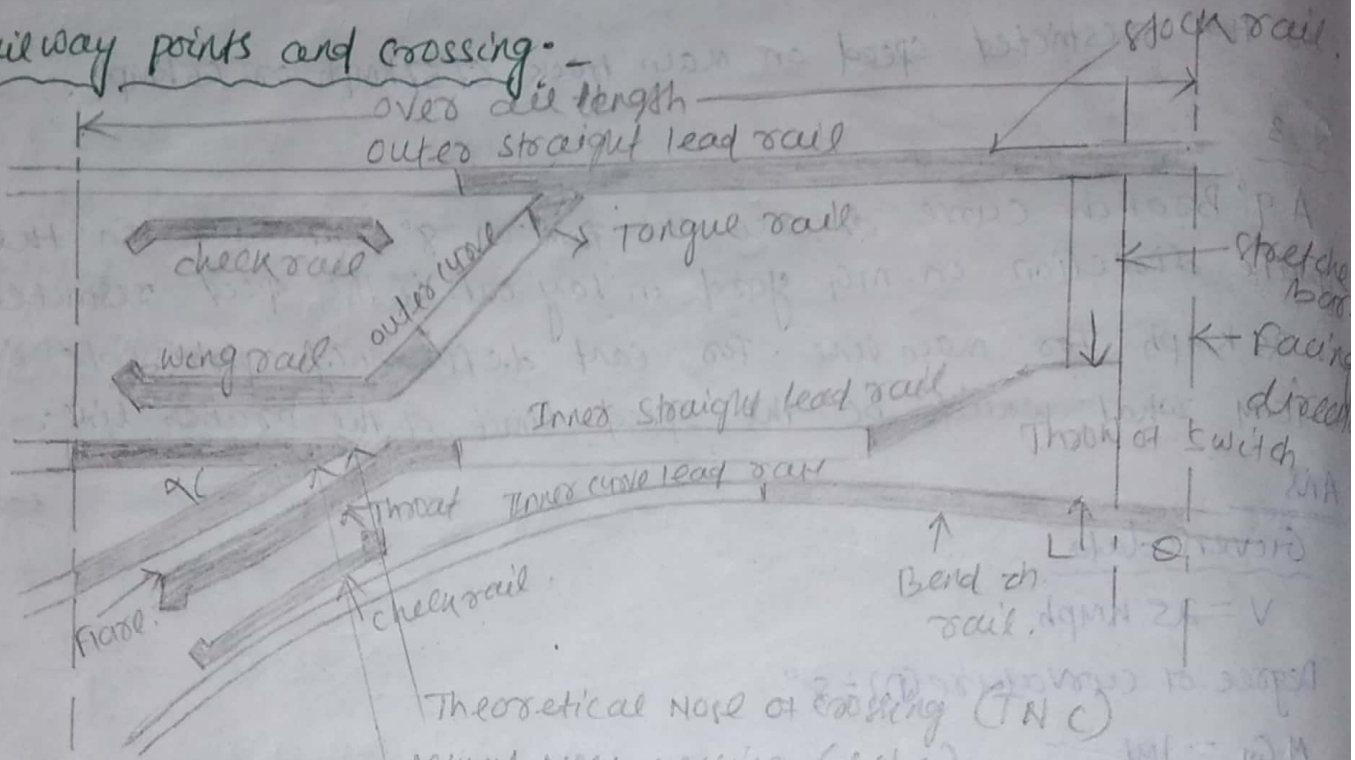
Cant defficiency of 5.1 C.M which is permissible speed of the train will be for a cant 5.1 + 2.82 = 7.92 C.M

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

$$\Rightarrow 7.92 = \frac{1 \times V^2}{1.27 \times 191.11}$$

$$\Rightarrow V = 43.84 \text{ kmph.}$$

Railway points and crossing:-



Points and crossing:-

Points and crossing are special arrangement on the track to facilitate smooth division of trains from one track to another.

Turn out:-

→ Turn out is an arrangement of points and crossing with lead rail by which trains may be diverted from one track to another moving the facing direction.

→ These are the following parts of turn out.

a) A pair of point.
b) A pair of switches.
c) A pair of stock rail.
d) A vee crossing.
e) Two check rail.
f) four lead rail.

g) Bearing plate.
h) slide chair
i) stretcher bar etc.

Neccessity of point and crossing :-

→ points and crossing provide flexibility of movement by connecting one line to another according to requirement.

→ They also help for imposing restriction over turnout which neccessity retard the movement

→ From safety aspect it is also important as points and crossing are weak point in the track and vehicles are to be deraiment at these places.

Important terms used in points and crossing :-

i) Facing direction :-

If someones stands toe which and looks towards the crossing then the direction is called as facing direction.

ii) Trailing direction :-

If some ones stands at the crossing and look towards the switches then the direction is called trailing direction.

iii) Facing point the turn out :-

where train pass over the switches first and they pass over the crossing is called facing point of turn out.

iv) Trailing point the turn out :-

where train move in the opposite site of facing point in which the train pass over the crossing first and then over the switches is called trailing point the turn out.

v) Right hand turn out :-

If train from main track is diverted to the right of the main route in the facing direction then this diversion known as right hand turn out.

vi) Left hand turnout :-

If a train from main track is diverted to the left of the main route in the facing direction then this diversion known as left hand turn out.

vii) Right hand switches & left hand switches :-

These are termed as left hand switches or right hand switches depending open left or right when seen from the facing direction that is stand at the point are look towards the crossing.

viii) switches :-

A pair of tongue rail, stock rail with necessary connection and fitting from a switch.

ix) stock rail :-

They are the main rail of the track to which the tongue rail fit.

x) Tongue rail :-

These rails lie betw the two stock rail and are tapered to a point or tongue 0.64 C.M to 0.95 C.M wide.

xi) Distance blocks :-

These blocks are inserted betw the tongue rail & stock rail.

xii) stretcher bar :-

The does of both the tongue rail ~~& stock~~ are connected together by means of stretcher bar.

Types of switches

They are two types such as

i) Stub switch.

ii) Split switch.

i) stub switch :-

In this type of switch no separate tongue rail is provided and some portion of the track is moved from side to side.

→ It is an old form of the switch and has got many objection in its performance.

Split switch :-

In this type of switch a tongue rail is ~~called~~ combined with the stock rail. split switches are classified are

a) on the basic of fixator at heel.
   → loosed heel type.
   → fixed heel type.
   → under cut switches.
   → over cut switches.
   → straight cut switches.

Loosed heel type :- (Articulated type)

→ In this type tongue rail are joint to lead rail by means of fish plate.

→ The two front bolt are keept loose to allow the throw of switch and these bolts are kept tight when the tongue is open.

→ This is suitable for short length switches.

Fixed heel type :- (Spring type or flexible type)

→ This switch is an improvement over loose heel type switch.

→ In this all the four bolts are type when the tongue is closed.

→ This is suitable for long tongue rail only.

Under cut switches :-

→ In case of the height of stock rail and tongue rail is same it is desirable to cut out a portion of flange at the foot of the stock rail so that the toe of the tongue rail switch is called as under cut switches.

→ This switches are used in narrow gauge line.

Over riding switches :-

→ In this type separate rail section of stock rail and tongue rail are adopted.

→ The stock of heavy section and tongue rail of light section are used instead of cutting. The flange rather than weakning the stock rail are in case of under cut switches.

→ The tongue rail in this type rides over the flange of the stock rail. This termed as over riding switches.

→ It is used in BG and MG track.

Straight cut switches :-

→ In this type the tongue rail is cut straight in the line with the stock rail is termed as straight cut switches.

→ This is turn increase the thickness of toe of toe of the tongue rail which increases the strength. It is used for bull headed rail.

Crossing :-

A crossing or a frog is a device which provides two flange way through which the wheels of the flange may move when two rails intersect each other at an angle.

Component part of crossing :-

→ A crossing or Vee-bee
→ points & splice rail.
→ wing rail.
→ check rail.
→ chair at crossing.

Requirement & characteristics of good crossing :-

→ The assembly of a crossing has to be rigid to stand against sevier vibration which cause loosing of the component.

→ The ware on parts of the wing rail opposite the nose and also of nose it self must be protected. This can be achieved by use of special steel.

→ The crossing body should be as rigid as possible and as long as practicable.

→ The nose crossing should have some thickness from practical consideration.

Types of crossing :-

a) On the basic of shape of crossing.

i) acute angle crossing or V crossing or frog.

ii) obtuse angle crossing or Diamond crossing.

iii) square crossing.

b) on the basic of assembly of crossing

i) spring or movable wing crossing.

ii) Ramped crossing.

1) acute angle crossing :-

→ This type of crossing is widely used

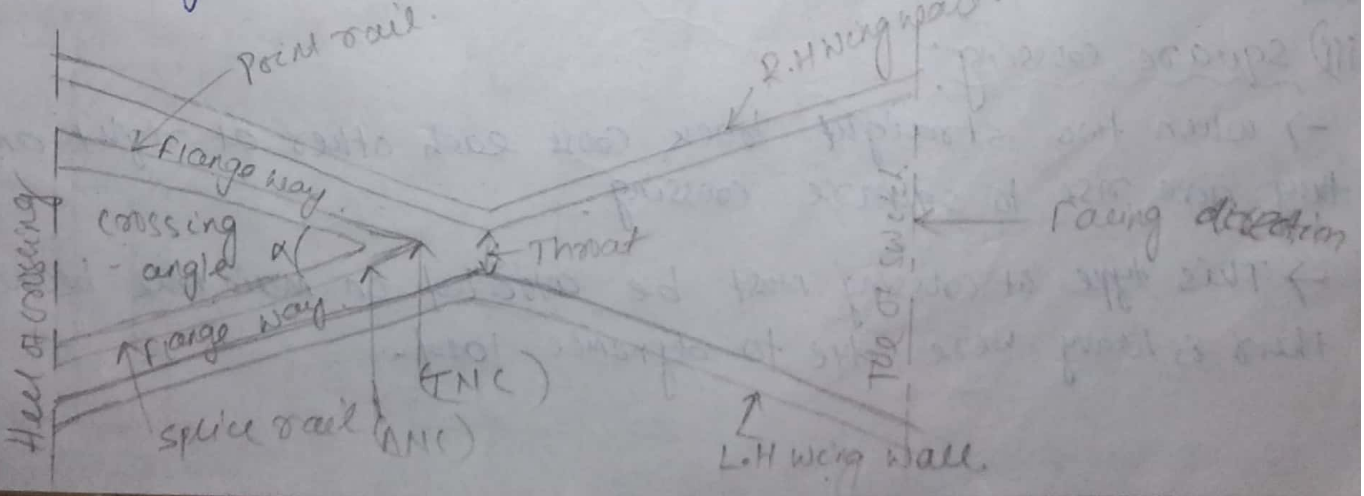
→ This crossing is offend when left hand rail of one track crosses a right hand rail of another track or viceversa.

→ If the angle of intersection of the approaching rail is acute angle it is termed as acute angle crossing.

→ It consist mainly of point and splice rail, wing rail, check rail.

a) point and splice rail

→ An acute angle is form either by point rail, and a splice rail or by combination of two point rail.



→ These are made of a special steel (i.e alloi steel)

b) A pair of wing rail :-

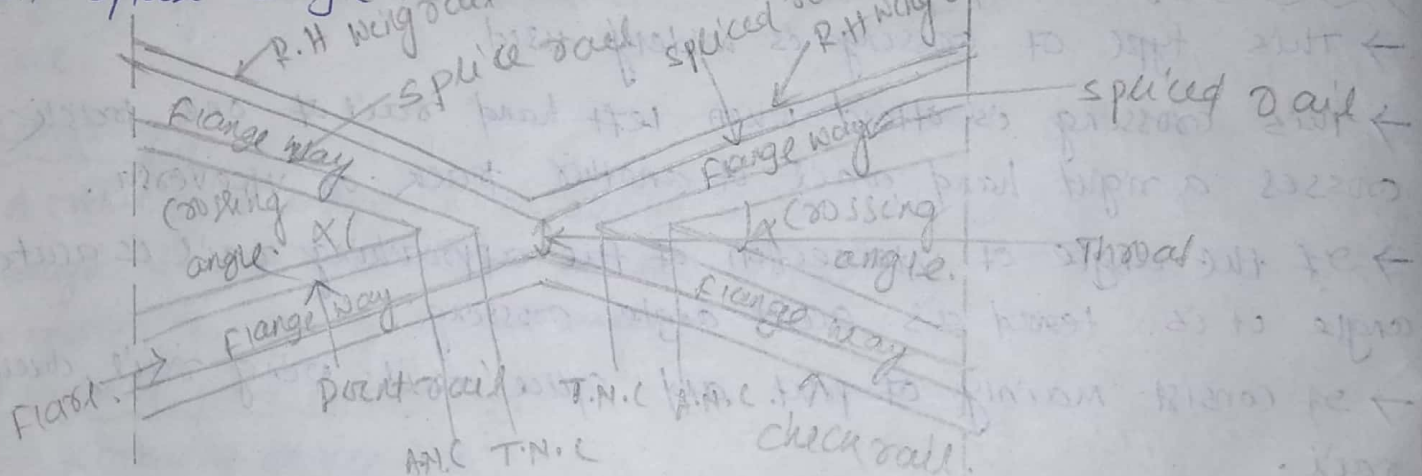
→ These are bend at the ends one end of the wing rail is connected to lead rail where as the other end is flare. This flaring is done to facilited the entry and exit of flange wheel to the gap.

c) A pair of check rail :-

These are subsidiary rail paralel to the running rail. They are flared at end for guiding the wheel flanges.

ii) Obtuse angle crossing :-

This crossing is offtend when left hand rail of one track crosses right hand rail of another track or viceversa at an optuse angle.

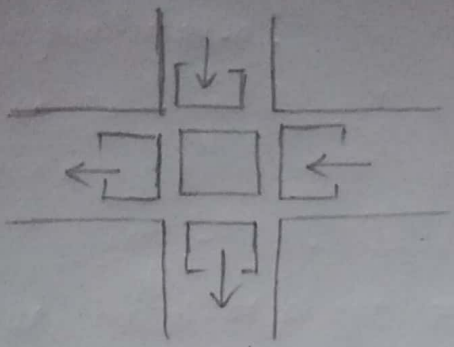


→ In case of optuse angle crossing the long wing rail does carry the wheels as in case acute angle crossing rather act as check rail.

iii) Square crossing :-

→ When two straight track cross each other at right angle they give rise to square crossing.

→ This type of crossing must be avoided on main line because their is heavy wear due to dynamic load.



b) i) Spring on movable crossing:-

→ In such a crossing one wing rail is movable and is held against vee of the crossing with a ~~stong~~ strong helical spring.

→ It makes the main track continuous and this crossing because very useful when there is high speed traffic on main track and light speed traffic on the branch line or a turnout. This type of crossing is use USA.

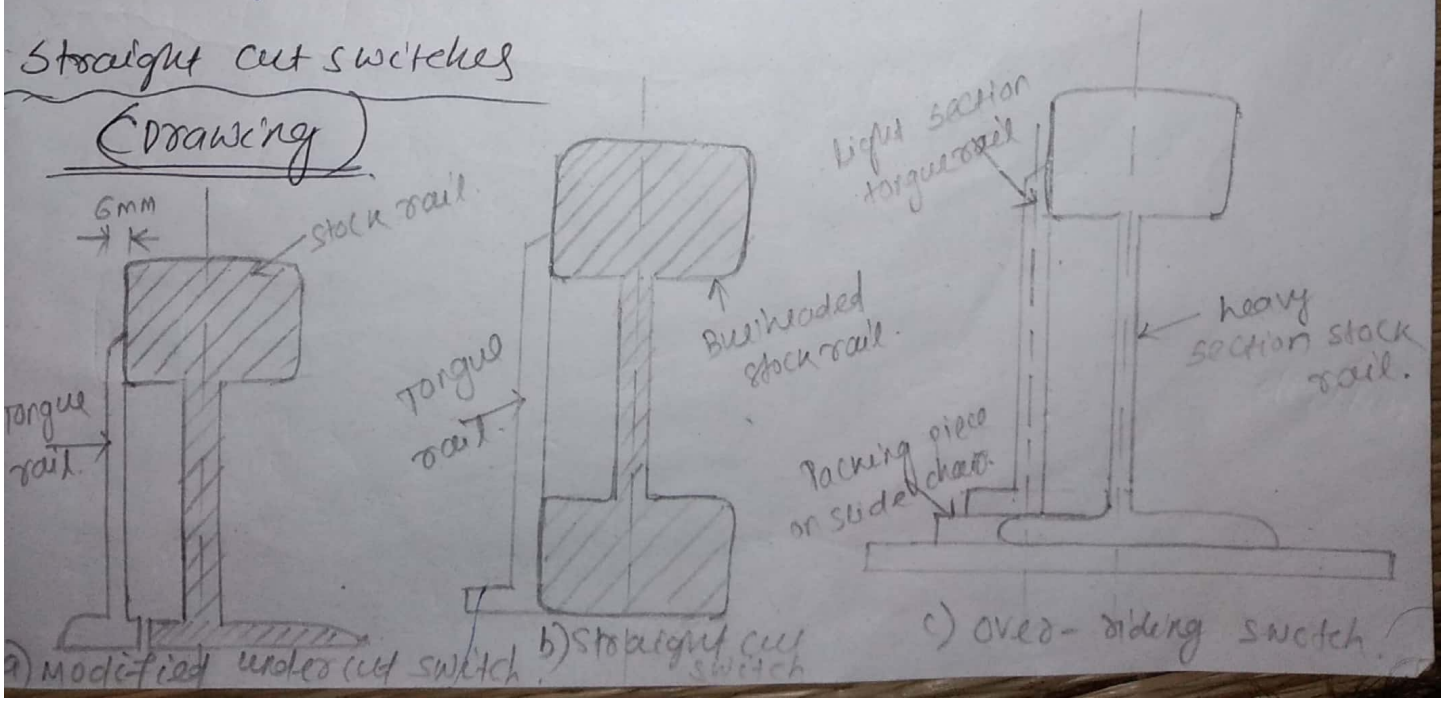
ii) Ramped crossing:-

→ In case of complicated yard lay out with heavy but slow speed traffic. The throat to nose clearance is negotiated by use of special Maganese steel block over long distance.

→ The entire wheel load comes on the flange and this type of crossing may be used of safety for slow speed.

Straight cut switches

Drawing



BRIDGE (58) Dt - 10/02/2020

Introduction :-

→ It is a communication rule provided when their is any obstruction to the traffic.

→ A bridge is a structure which provides passage facility over an obstacle.

→ The required passage may be for a railway track, roadway.

→ The obstacle to be crossed may be deep valley full of water, river etc.

Component of Bridge :-

The bridge structure can be devided into two parts

~~i)~~ Super structures

ii) Sub structure or foundation.

i) Super structures :-

It is that part of a bridge over which the traffic Move safely. It consists of parapet, road way, girder, Arches, trusses over which the road is support.

ii) Sub structure or foundation :-

→ The function of sub structure is similar to the function of foundation provided in the building thus the sub-structure support the super structure and distribute the load to the soil below.

→ The sub structure consist of foundation, piers, abutment, wing wall approaches they all support the super structure of the bridge.

Classification of bridge :-

Bridge can be classified in to various types depending upon the following factores

i) Classification according to material wise

a) Timber bridge
b) Steel bridge.
c) R.C.C bridge
d) Masonary bridge
e) Composite bridge.

ii) Classification according to alignment of bridge

a) Straight bridge
b) Skew bridge.

iii) According to location of bridge flow

a) Deck bridge
b) Semi through or through bridge.

iv) According to purpose

a) Highway bridge
b) Railway bridge
c) foot bridge

v) According to ~~purpose~~ Nature of superstructure

a) portal frame bridge.
b) Truss bridge.
c) Balanced cantilever bridge.
d) suspension bridge.

vi) According to position of high flood level

a) Submergible bridge.
b) Non submergible bridge.

vii) According to life of bridge:

a) permanent bridge.

b) Temporary bridge.

viii) According to fixed or movable bridge

a) Swinging bridge.

b) Bascule bridge.

c) Lift bridge.

ix) According to span of bridge

a) culvert bridge (span less than 6Mt)

b) Minor bridge. (span betwn 6 to 30Mt)

c) Major bridge (span more than 30M)

d) long span bridge (span more than 120M)

x) According to types of connection:-

a) Pin connected bridge

b) Riveted connected bridge.

c) Welded bridge

Selection of Bridge site:-

→ The selection of site for bridge is done considering the economy and safety.

→ The place of site is determine by the position of road or railway or mainly there are two possible crossing of the road or railway line over a river.

a) Simple right angle stream crossing.

b) stream crossing on skew angle.

→ But if the position of railway line or road alignment doesnot influence the site the following factores governed.

Selection of an ideal site for the bridge :-

→ Straight reach of the stream.
→ Well define fixe bank.
→ stream line flow.
→ Minimum width and right angle crossing.
→ Form foundation.
→ Availability of construction material.
→ Labour.

a) Straight reach of the stream :-

Both the upstream and downstream side of the river should be straight because this will ensure smooth and uniforms flow.

b) Well define fixe bank :-

→ All the site of the bridge both sides banks should be permanent and high.
→ This site bank showed be free form erosion, ~~collapse~~ Collapse by impact of water in high winds & flood.

c) Stream line flow :-

At the site of the bridge the river should have streamline flow because turbulent flow causes scour in the bed.

d) Minimum width and right angle crossing :-

This means chipest bridge when ever possible small stream may be diverted to cross a right angle instead of skew angle.

e) Form foundition :-

The nature of soil in the bed most provide good foundation.

f) Availability of construction material :-

The situation of bridge showed be such that plenty of good hard and durable material for the construction of bridge are available near the site.

g) labour

A site where labarous for the construction of bridge are available in nearby localities.

Bridge alignment :-

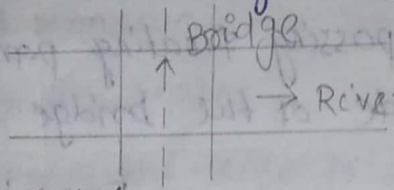
Depending upon the angle which it's the bridge makes with the axis of the river the alignment can be of two types.

i) square alignment.

ii) skew alignment.

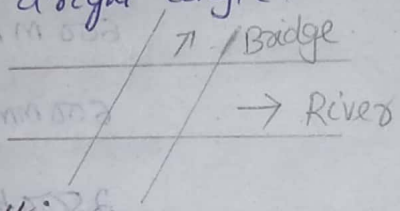
i) square alignment :-

In this bridge it's act right angle to the axis of the river.



ii) skew alignment :-

In this the bridge it's act some angle the axis of river which is not a right angle.



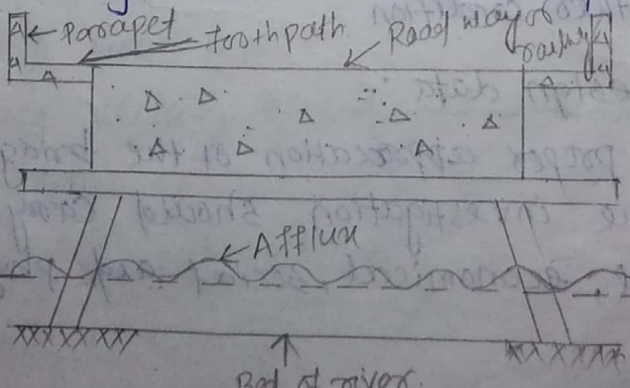
iii) waterway :-

The area through which the water flows under the bridge super structure it's known as water way of the bridge.

AFFLUX :-

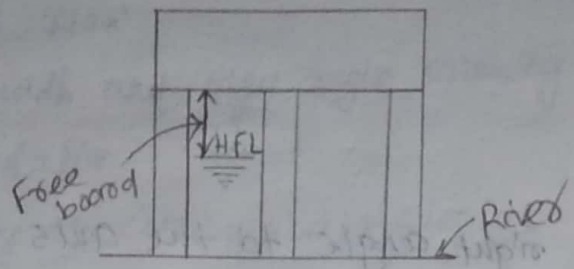
→ The rise in water level of the river, near the bridge due to obstruction created by the construction of abutment and piers is called afflux.

→ When the effective linear water way of a bridge is less than the natural width of the river immidiately of the upstream side of the bridge afflux is created.



Free board :-

→ It is the vertical difference betn the design high flood level allowing for affluxion and the lowest part of the bridge structure.



→ Free board is provided for passing floating parts, fallen trees, Trunks, boats etc from one side of the bridge to the other side.

Types of BRIDGE	Free board
1) Arch Bridge	300 MM
2) High level Bridge	600 mm.
3) Girder Bridge	600 mm to 1000 mm.
4) Navigation stream Bridge	2500 to 3000 MM

Economic span :-

→ Economic span of a bridge is the one which reduce the overal cost of a bridge to be a minimum.

→ The overal cost of a bridge depends upon the following factors

i) cost of material and its Nature.
ii) Availability of skilled labour.
iii) Span length
iv) Nature of skilled
v) Climatic and other condition.

Collection of Bridge design data :-

For a complete and proper appreciation of the bridge project. the engineer incharge of the investigation should carry out study regardings it financial, economical, social and physical possibility.

1) Design data for major Bridge :- (GY)

a) General data

i) Name of the road and its classification.

ii) Name of the stream.

iii) location of bench mark and its reduce level.

iv) existing arrangement for crossing the stream.

* During monsoon.

* During dry season.

v) liability of the site to earthquake.

2) Catchment area of run off data :-

i) Catchment area

* on hilly part.

* on plane area.

ii) Maximum rainfall intensity

iii) Length and width of the catchment area.

iv) Cross slope of catchment area.

v) The nature of catchment.

3) Data regarding nature of stream :-

i) The stream can be perennial or seasonal.

ii) River banks at the proposed side can be

* firm

* firm

iii) ordinary flood level.

iv) Surface velocity of LWL (Low Water level)

v) Bed slope at the LWL.

vi) Bearing capacity of soil.

vii) check erosion.

4) Data regarding alignment and approaches :- (G5)

→ The purposed alignment of the bridge can be skew & square.
→ In case of curve approaches the purpose radii of the curve is determine.
→ The purposed gradient in approaches are determined.

5) Super structure data :-

→ proposed clear roadway over the bridge.
→ proposed width of footpath.
→ camber or road formation.
→ The proposed bridge can be design to pass maximum flood or ordinary flood or only dry season discharge.

6) substructure or foundation data :-

It may be open foundation, well foundation, R.C pile foundation

7) Data or existing structure :-

→ position of existing bridge on index plan.
→ Details of existing bridge.
  a) size and number of span.
  b) Types of substructure.
  c) types of superstructure.
  d) Type and depth of foundation.

8) Miscellaneous data :-

→ Name of nearest inhabited locality.
→ facilities available for accomodation and site for construction staff.
→ Nearest railway station and its distance from the site means of transfer for material.
→ Availability unskilled & skilled labour for diff^{n} tread requirement for construction.
→ Availability of electricity.

→ Nearest place of availability of cement, steel & timber.
→ Availability & quality of stone from the nearest quarries for stone masonary work. (66)
→ The following drawing should be prepared
a) key map
b) Index plan
c) Contour survey plan.
d) Site plan
e) Longitudinal section.
f) Soil profile.
g) catchment area map.
h) Detail drawing of foundation, super structure & substructure
i) Elevation, section & plan of bridge.

→ The physical properties of the soil required of the bridge size is very essential for correctly deciding the location and type of foundation.

→ The complete subsurface investigation can be done as follows
i) Measure of the soil deposite up to the sufficient height.
ii) Depth, thickness & composition of soil stratum.
iii) The location of ground water.
iv) Depth to rock.
v) The engineering properties of soil.
a) In exploration programme the extend of distribution of diffⁿ soil both in the horizontal & vertical direction can be determine by the following method.

* By use of open pot.
* By making bore hole.
* By sounding.
* By geophisical Method.

Scour depth :-

When the velocity of the stream exceeding the limiting velocity scour occurs the normal scour depth of the water in the middle of the stream.

Depth of foundation :-

→ The depth of bridge foundation is determine by consideration of the same bearing capacity of soil after taking in to account the effect of scour.

→ The minimum depth foundation can be approximately calculated by the following relationship.

$$h = \frac{P}{W}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

where,

h = height of the foundation.
P = Bearing capacity of soil, i.e kg/m^2
W = specific weight in kg/m^2
ϕ = Angle of internal friction of the soil.

Types of foundation of Bridge :-

Foundation is the part of the structure which is in direct contact with load and transmit them to the ground or soil below. Generally 4 types of foundation their

i) spread foundation.
ii) pile foundation.
iii) well foundation.
iv) cassion foundation.

i) spread foundation :-

This type of foundation in shape is similar as provided for walls. It is provided in such situation where the scouring of the river bed is minimum. This type of foundation can also provided even if the bed contains sand but scouring is prevented by driving piles the minimum depth of this foundation is

$$h = \frac{P}{w}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

where,

h = Height of the foundation.

P = Bearing capacity of the soil i.e kg/M^2.

w = weight in specific in kg/M^2

ϕ = Angle of internal friction of the soil.

ii) Pile foundation :-

→ The pile foundation is construction for the foundation of a bridge piers or abutment supported on the pile. A pile is an element of construction composed of timber, concrete steel or a combination of them.

→ Pile foundation may be defined as a column support type of foundation is cast in situ or precast. This type of construction is adopted when the loose soil extends to great depth.

a) Pile driving

The process of forcing a pile in to the ground is known as pile driving. The equipment required for pile driving are pile frame, pile hammer, Lead, winches.

b) Pile frame

Pile frame are generally made of steel having height varrieng betwn 10 to 25M.

c) Pile hammer

The hammer is guided betwn to parallel steel member known as lead. Hammer are of following types,

i) Drop hammer.
ii) Single acting steam hammer.
iii) Double acting steam hammer.
iv) Differentiate acting steam hammer.
v) Vibratory hammer.
vi) Disel hammer.

i) Drop hammer

A drop hammer is lifted and allowed to fall on the head of a pile. The weight of hammer varries from 1 to 4 ton and the height of fall varries 1.5 to 6 mt.

ii) Single acting steam hammer

In this type of the hammer is rest either by steam or by compress air and then allow to follow by gravity. The weight of single acting steel hammer about 2 ton. The fall is about 1m height and the weight ~~and~~ of the blow is about 60 per minute.

iii) Double acting steam hammer :-

In this type the hammer is raised and lower either by steam or compressed air the weight of double acting steam hammer is about 500kg but together with steam pressure. It has an effect of a weight about 3 ton the number of blows per minute is about 100 to 200.

iv) Differentiate acting steam hammer :-

This hammer combines the advantages of single acting and double acting steam hammer. The weight of hammer and height of fall as same as incase of single acting hammer. The number of blow per minute is same as in case of double acting hammer.

v) Disel hammer :-
The disel hammer is a small light weight self containt and self activating pipe using gasoline for fuel.

vi) Vibratory hammer :-
In this type the driving unit vibrate at high frequently.

Lead
They are employed to guide the hammer and pipe.

Winches
These are required to leave the hammer and pipe.

coffer dam
It is a temporary structure which is constructed so as to remove water or soil from an area and make it possible to carry on the construction wall under reasonabely dry condition.

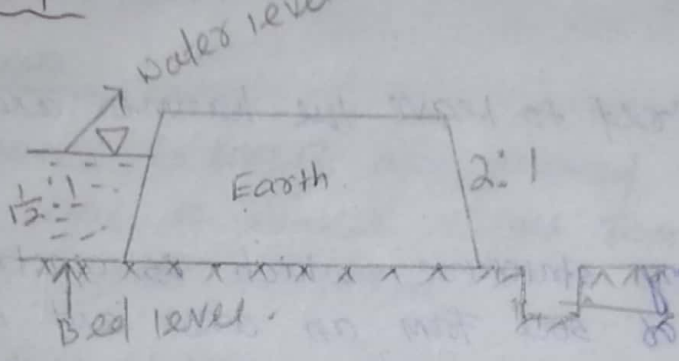
Requirement :-
→ constructed at site work.
→ It should be water tight.
→ Absolute water tightness in not required.
→ It should be cost effective.
→ It have advantage where large area of site is to be enclosed and hard bed responsible.
→ It should be design for maxm water level and other destructive force to make it stable against bursting.
→ Material used can be timber, steel, soil, concrete.
→ Types of construction depend undepth, soil condition, material etc.
→ Water excluded by coffer dam can be ground water deep or running water etc.

Types of coffer dams :-

There are six types of coffer dams used for bridge construction

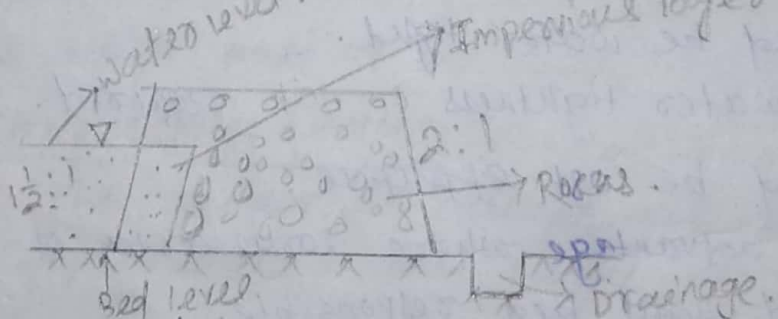
i) Earth filled.
ii) Rock filled.
iii) Rock filled crip.
iv) Single wall
v) Double wall
vi) Cellular.

i) Earth filled



→ This is the simplest form of cofferdams its use is limited
→ It should never be used where their is danger of over topping by water.

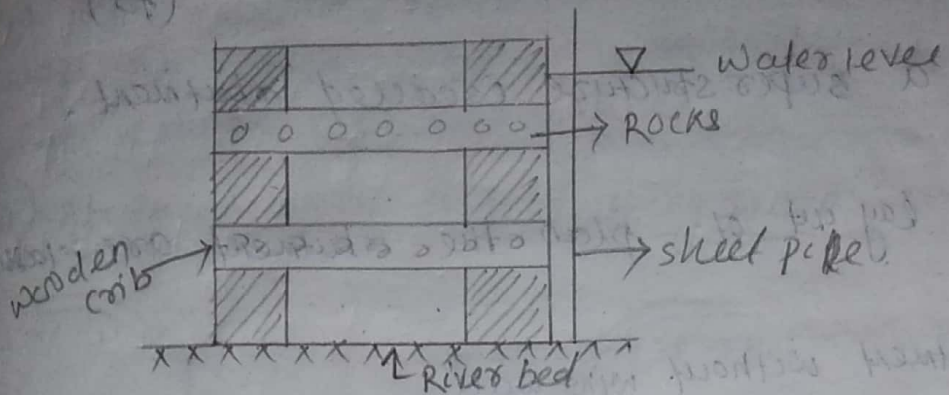
ii) Rock filled



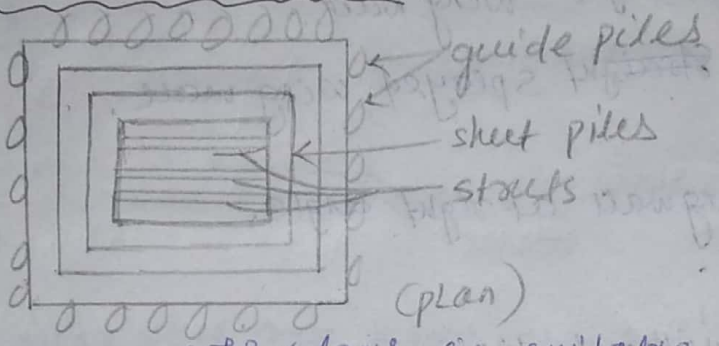
→ They are constructed by placing rock along stream. They can be used for a depth of water upto 3mt. They are economical in places where rock is available in plenty.
→ An impervious layer of earth is laid on the outer face of the coffer dam.

iii) Rock filled crip

→ A rock filled crip cofferdam is comprised of timber crips a crip is a frame work of wooden horizontal and cross beams laid in alternate course.



iv) Single wall cofferdams :-



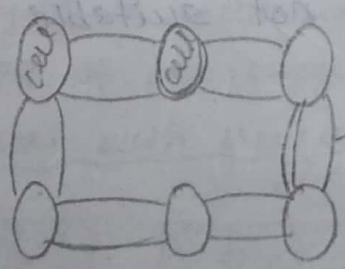
→ This type of cofferdams is suitable when available working space is ~~limited~~ limited and area to be enclosed is small.

→ It may be use upto maxm depth of water of 25mt the walls of a cofferdams are normally made of steel sheet piles.

v) Double wall

The double wall cofferdams are provided to enclosed of large area. The double wall gives stability to the cofferdams.

vi) Cellular cofferdams



→ They are made of steel sheet piles and are suitable for dewatering in large area. They are comprised of cells or circular cells or modified circular cells.

Abutment :-

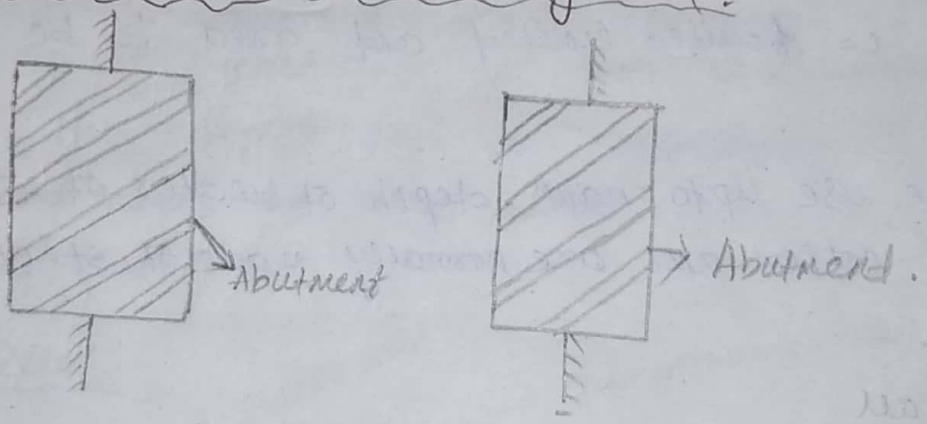
The end support of a superstructure is called abutment.

Types of abutment

According to the lay out of plan the abutment are classified as below;

i) Straight abutment without wing wall.
ii) Abutment with straight wing wall.
iii) Abutment with ~~Straight~~ splayed wing wall.
iv) Tee Abutment.
v) Abutment with wingwall at right angle.
vi) pulpit Abutment.

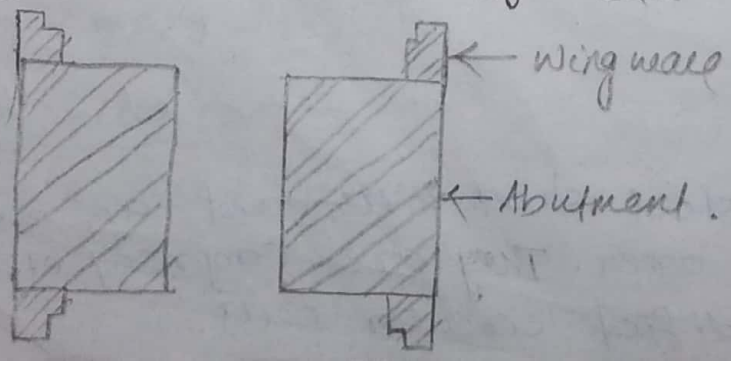
i) Straight abutment without wing wall :-



→ This type of abutment are not generally adopted on water ways. As the flood will penetrate through the joints of masonary on to the earth.

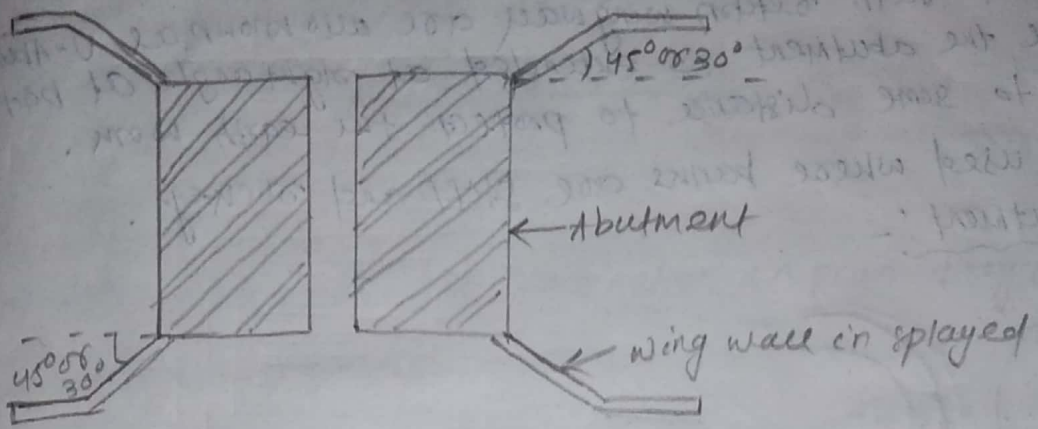
→ This will reduce the bearing capacity of the soil and damage it. Thus this type of abutment are not suitable for water ways.

ii) Abutment with straight wing wall :-



→ This type of abutment are also not suitable for water ways as the water flow immidiately behind the wing wall and damage the embankment.

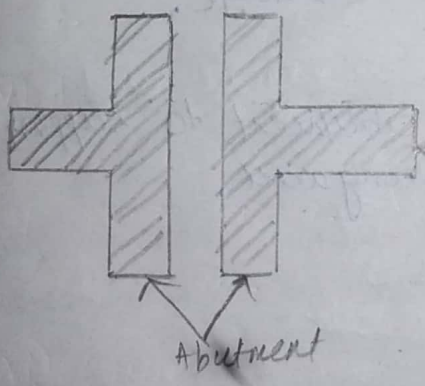
iii) Abutment with splayed wing wall :-



→ This wing wall are made straight but they are splayed at angle 45° or 30° with the face of abutment.

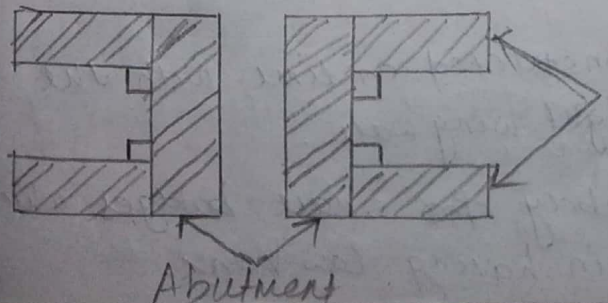
→ The abutment with splayed wing wall are used across a river to provide smooth entry and exist of water.

iv) Tee ~~beam~~ abutment :-



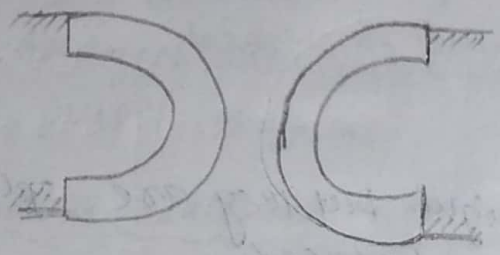
→ This type of abutment were used in early rail, road, construction, The head of tee support the bridge.

v) Abutment with wing wall at right angle :-



→ The wing wall are run back in to the fill.
→ The wing walls are parallel are to the roadway. This type of abutment are suitabely where rock slow make in possible to setup the wing wall footing.
→ The abutment with return wing wall are also known as U-Abutment. In this type the abutment is extended at right angle at both the ends to some distance to protect the earth work.
→ These are used where banks are stiff and rockey.

vi) Pulpit abutment :-



→ It is a modify U-abutment where the arms of wing at right angle are made shorter.
→ The return wing wall should be of sufficient length to prevent the retaining material from flowing on the bridge.

Wing wall

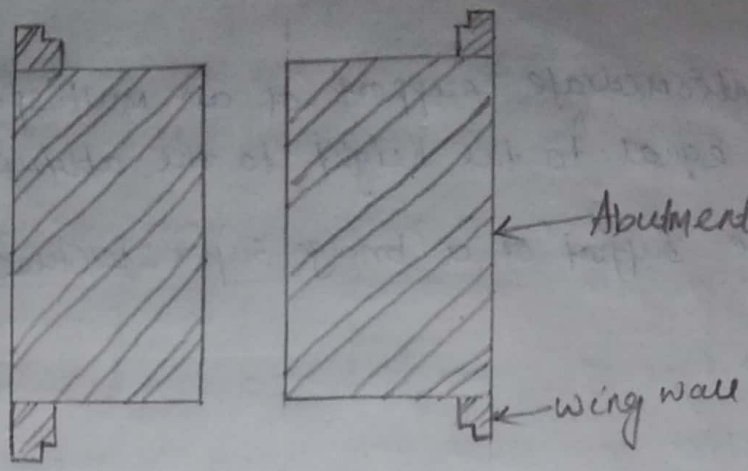
The wall constructed on either side of abutment to support and protect the embankment are known as wing wall.

Types of wing wall

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

1) Straight wing wall :-

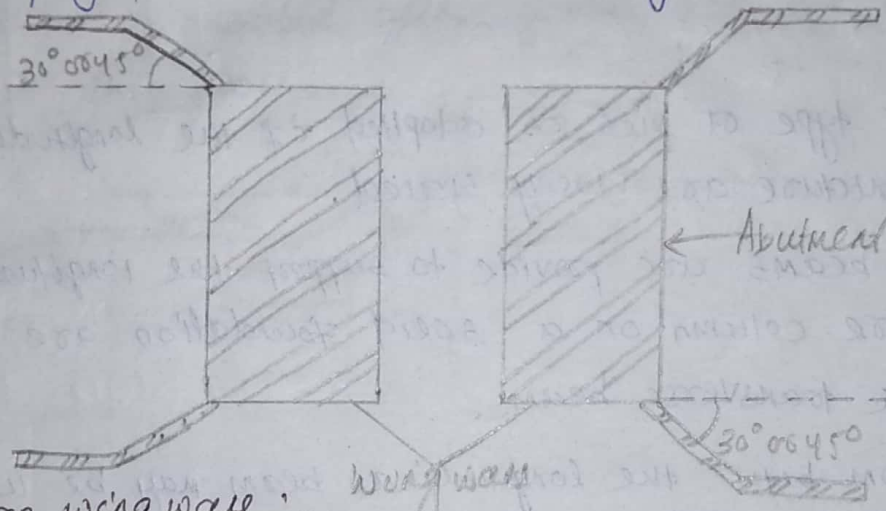
→ When the wing wall are constructed in line with the abutment are known as straight wing wall.
→ This type of wing wall is suitabely for small bridges which are constructed across the drain having low bank.



2) Splayed wing wall :-

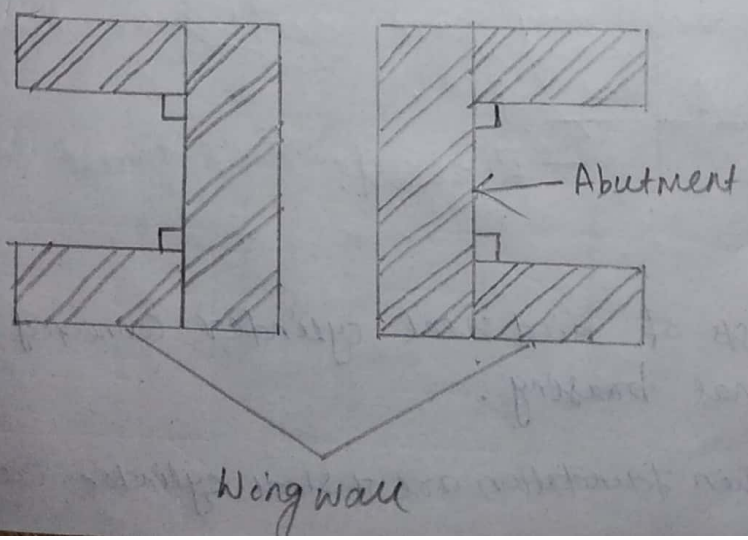
→ when wing walls are inclination in plan they are known as splayed wing wall.

→ The splayed or inclination is usually 45° or 30°.



3) Return wing wall :-

When angle of inclination become 90° the wing walls are known as return wing wall such wing walls are ~~provided~~ preferred to splayed wall in case of very high embankment.



Bridge piers :-

→ pier is an intermediate support of an multispan bridge its height generally kept equal to the height to the abutment.

→ The intermediate support of a bridge superstructure is known as pier.

Types

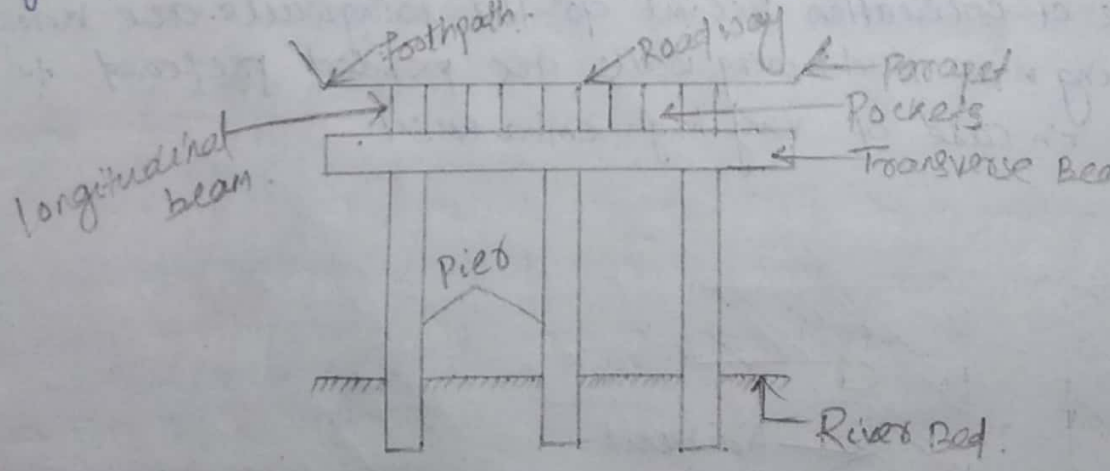
1) Column bent.
2) Cylindrical pier
3) Dumb bell pier.
4) Pile bent.
5) Solid pier.
6) Trestle pier.

1) Column Bent :-

→ A column bent type of pier is adopted if the longitudinal beam of the superstructure are closely spaced.

→ The transverse beams are provide to support the longitudinal beam and two or more column on a solid foundation are constructed to support the transverse beam.

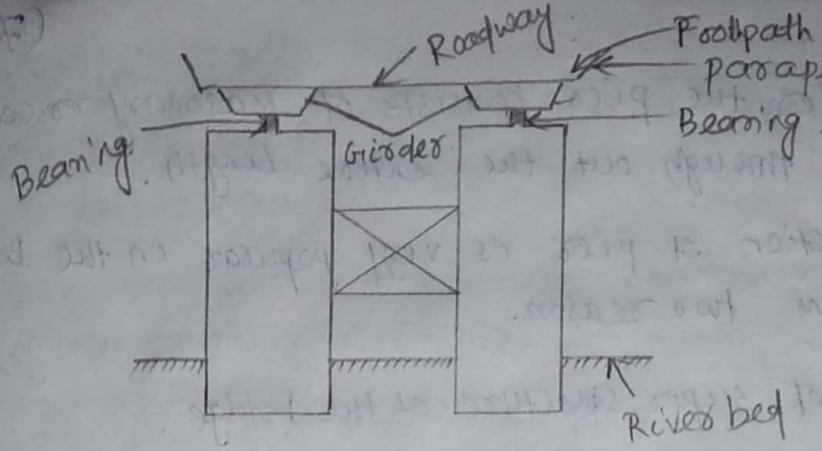
→ The pockets from betwn the longitudinal beam may be used to carry gas pipe, waterpipe and sewage pipe.



2) Cylindrical piers :-

→ A cylindrical pier consists of mild steel cylinder connected by the horizontal and digonal bracing.

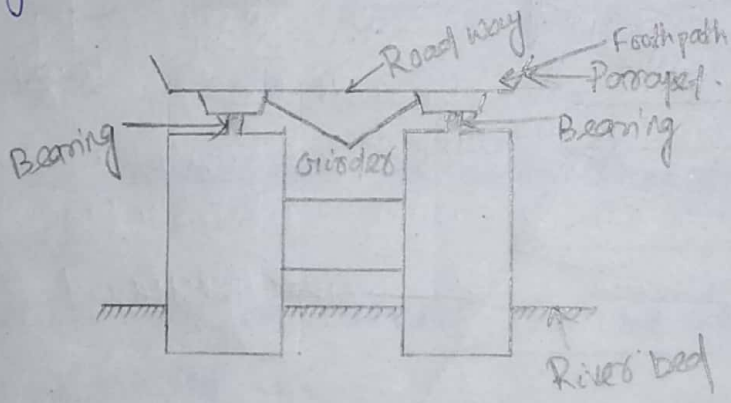
→ These pipes are adopted when foundation are of steel cylindrical caisson type.



3) Dumb Bell pier :-

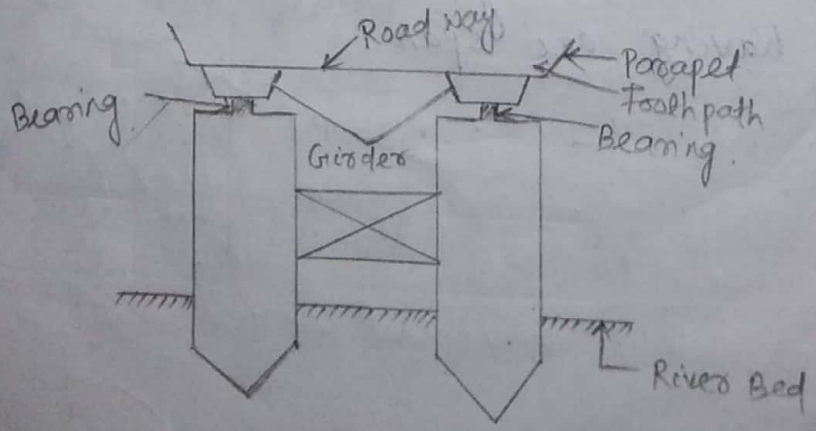
→ A Dumb bell pier has an appearance of a dumb bell it is adopted when the superstructure of a bridge supported on twin girder.

→ A column is provided below girder and the column is connected by a thin wall.



4) pile bent pier :-

In case of pile bent pier the girders of super structure of a bridge supported on RCC pile. The pile bents are use for low piers over unstable ground.



5) Solid pier :-

→ In case of solid pier the pier consists of masonary or cement concrete solid section through out the entire length.

→ Such types of construction of pier is very popular in the bridge construction mainly from two reason.

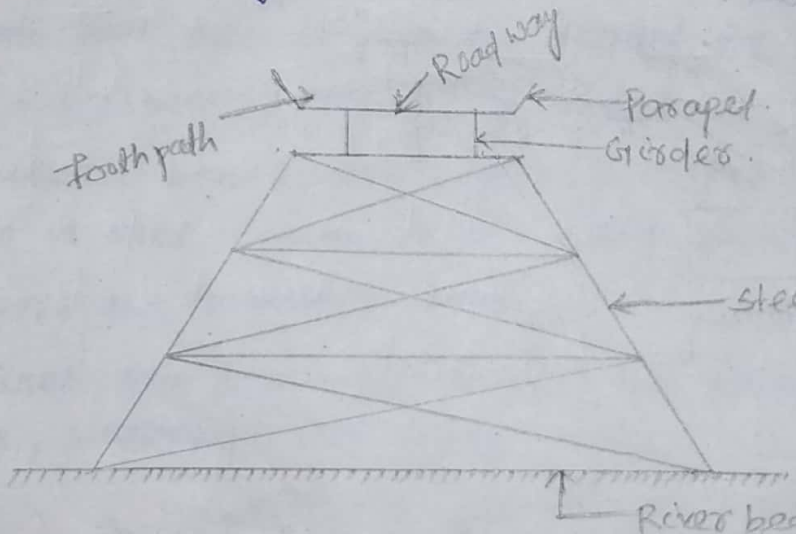
i) For any type of super structure of the bridge.

ii) It provides excellent resistance to the action of floating bodies.

6) Trestle pier :-

→ A trestle is a frame pier and it consists of vertical, horizontal, diagonal main bars.

→ The trestle bent may be of steel or concrete.



Culvert :-

A culvert is a small bridge used for carrying water from one side to another. A culvert may have one, two or more spans. Mostly culverts having one span.

Types of culvert

1) Arch culvert.
2) Slab culvert
3) pipe culvert.
4) Box culvert.

1) Arch culvert

→ An arch culvert consist of abouments, wing wall, parapet and foundation.

→ The construction materials commenly used are brick work or concrete.

→ If the bed soil is good their is no necessary of providing floor. If the soil is poor and their is scouring of soil then floor is provided.

2) Slab culvert

→ A slab culvert consist of R.C.C slab suitabelly supported on walls.

→ A slab culvert of simple type are suitabelg up to maxm span of 2.5 Mt.

→ The construction of slab foundation culvert is very simple.

→ This type of culvert can be used for highway as well as railway.

3) pipe culvert

→ They are provided when discharge of stream is small

→ usually one or more pipe of diameter not less than 600MM are placed side by side.

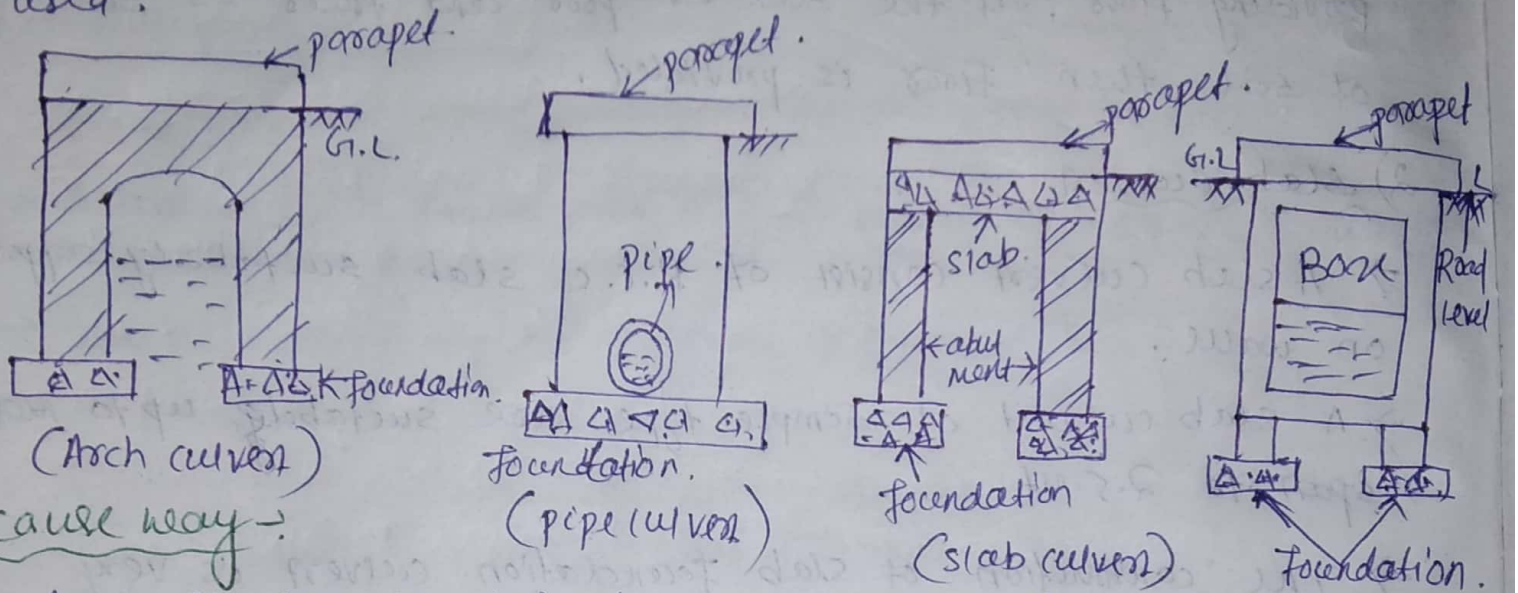
→ Their exact no. of diameter depends upon the discharge of water.

→ Pipe may be of masonary cement concrete iron or steel.

4) Box culvert

→ These culverts mainly consists of one or more no. of square or rectangular opening for passing the water from one side to another.

→ In soft soil when their is possibility of scouring and bearing capacity of soil is poor these culverts are mainly used.



Cause way :-

A cause way is defined as a small submersible bridge at or about bed level which will allow the flood to pass over it.

Types of causeway

1) Flush causeway.
2) Low level causeway.
3) High level cause way.

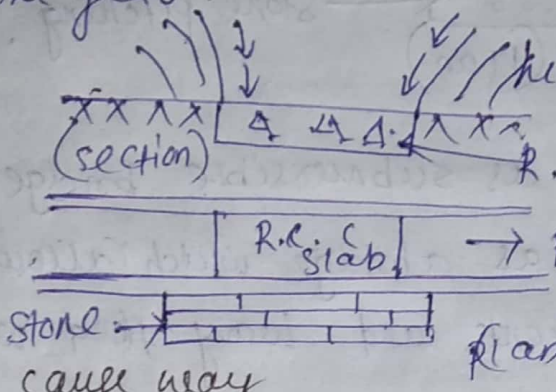
1) Flush causeway

→ In this type of cause way only pavement done in the stream bed and no vent is provided. The stream water flows continuously over the paved bed throughout the year.

→ some times R.C.C slab is provided in the bed level for giving smooth surface.

→ stone pitching is provided on the down stream side to protect the flooring.

→ Flush cause ways are provided in hilly areas when the maxm depth of water does not exceed 1.7 mtr in floods and the total interruption does not exceed 15 days in the whole period of one year.



2) Low level cause way

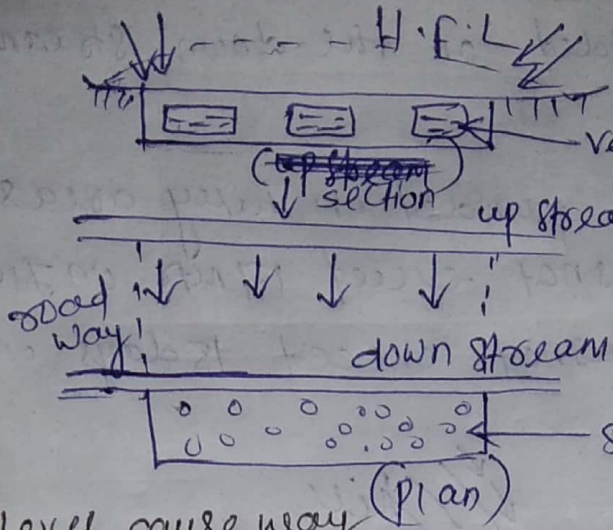
→ In some streams the depth of water generally remains about 30 C.M for most of period of the year. and the heavy discharge comes only in rainy season for a few hours only.

→ In such cases low level cause way are very useful for the traffic.

→ small openings about 30-35 C.M are provided below the road way slab, so that the winter and summer discharges can pass through these vents without disturbing the traffic.

→ Thus the most of the period can pass over the cause way with interruption. But in the rainy season just after rains heavy discharge comes which flows over the cause way and the traffic can stay in the rest constructed on the both side on the cause way.

→ when the flood is over traffic starts crossing the stream.



3) High level causeway

→ This is also called as submersible bridge.

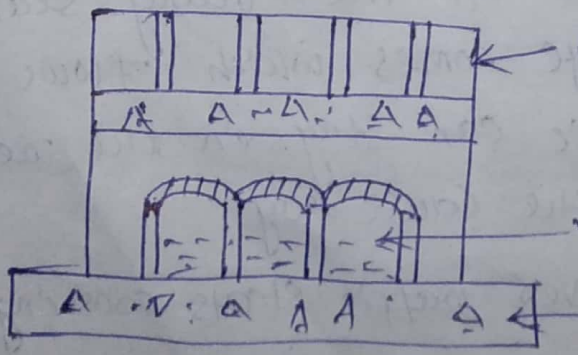
→ This may be defined as abridge which allows normal flood to pass through it's vents and heavy flood water pass over it.

→ These may be constructed on firm or rocky or loose soil bed. Thick cement concrete is first laid on the bed, over which vents of required section are constructed.

→ At the top of the vent R.C.C slab is laid over which graphic rules.

→ Small parapet are constructed on both side of road over the bridge.

→ Stone pitching or concrete is laid in the down stream side of the bridge.



Approaches

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

→ The alignment and levels of the approaches are affected by the design and layout of the bridge.

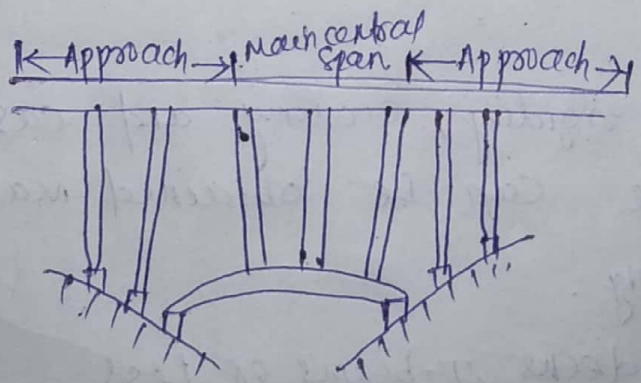
→ As per IRC recommendation they should have a minimum straight length of 15M either side of a bridge.

→ This length of 15M may be increased where necessary to provide minimum sight distance for the design speed.

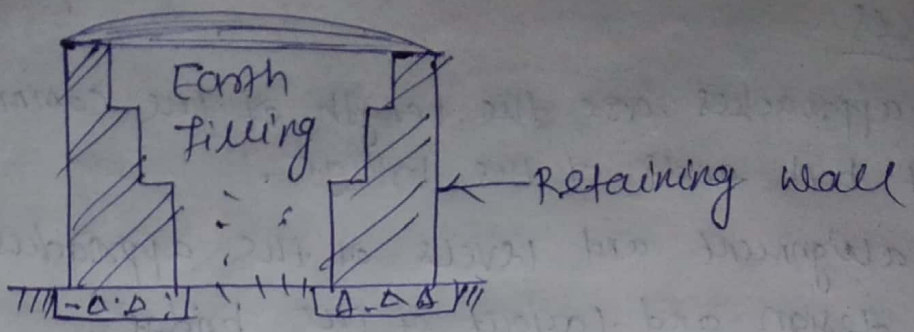
→ This straight length of approach should have minimum surfaced width equal to the roadway on the bridge itself.

Types of approaches

i) In case of arch and suspension bridge 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.



ii) In urban areas where land is costly the approaches are made of retaining walls constructed on either end of road width, and the earth work is filled in the middle. This type through higher in initial costs economical to maintain.



Masonary Bridge

→ Masonary arch bridges are very commonly used for road bridges of moderates span.

→ It is suitable for simplicity, economy and ease with which pleasing appearance.

→ Three types of masonary bridges are:

i) Stone Masonary arch.

ii) Brick Masonary arch.

iii) Cement concrete Masonary arch.

Reinforced cement Concrete bridges

→ It produced maintainance free structure.

→ No cleaning or painting after every five years is necessary.

→ The durability, rigidity, economy and ease width which pleasing appearance can be obtained make it suitable for bridge building.

→ It consists of decks, T-beams or less.

Types of reinforced cement concrete bridges

1) Slab bridges

→ It is the simplest type of reinforced cement concrete bridge and easiest to construct.

→ It is suitable for submersible bridge.

→ It is suitable for spans upto 8 metres. (86)

2) Girder Bridge

→ It is economical for spans betwn 10M to 20M.

3) Balanced cantilever Bridges

→ It consists of spans simply supported over cantilevers.
→ It can be used for spans varrying from 35M to 60M.
→ where foundation are expensive and small spans are uneconomical it can be used.
→ The cantilever span is usually 20 to 25M of the supported span.

4) Continuous Bridges

→ These are bridges continue un broken over more than one span.
→ End spans are made about 16 to 20% smaller than the intermediate span. It used for large spans.

5) Arch Bridges

→ These bridges can be economically used up to spans of about 200M.
→ The arches may be of barrel type or rib type.

6) Iron and steel Bridges

→ steel bridges are built for high way, railway track for support of water pipes, gas or oil pipes etc.
→ In india steel is used for very small spans to large spans.