A LECTURE NOTE

ON

RAILWAY & BRIDGE ENGINEERING

(TH-3)

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(INTRODUCTION)

It is the branch of engineering which deals with construction and maintenance of railway track for safe and efficient moment of train on it.

Classification of transportation:—

1. classification as per surface point of view:-

(a) Land transport
eg highways, railways, cable ways, ropeways etc.

(b) water transport
eg: canal ways, river ways, ocean ways, lakeways etc.

(c) Air transport
e.g Air ways

(2) classification according to communication

(a) Human porter
(b) Animal transport
(c) Road transport
(d) Rail transport
(e) Air transporter
(f) water transporter
(g) pipe line transporter
(h) pipe line transporter
(i) cable ropeway transportation.

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

(a) one degree Freedom:—

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

e.g:- railways, pipe line, conveyor system, cable ways.

(b) Two degree Freedom:-
These modes in which Vehicles can moves along a line as well as lateral i.e Vehicles to restrained only vertically.
e.g highway, Vehicles, shipboat

(c) Three degree of Freedom:—
These modes in which Vehicles are free to move in ~~any~~ any plane i.e Vehicles are neither lateral nore vertically restrained.
e.g Aeroplane, under water Vehicles.

(4) Classification according to energy used for moment
(a) human energy
(b) Animal energy
(c) Petrol and diesel energy
(d) steam energy
(e) solare energy
(f) Atomic energy
(g) Electric energy

Advantage of railways:—
(i) Political
(ii) social
(iii) Economical

i) Political advantages:-
→ Railways have united the people of different cast religion and tradition.
→ With the adequete network of railways the central administration has became more easy and effectiv

↳ Railways have contributed towards development of national ~~menten~~ mentality in the mind of people.

↳ The role of railway during engg. in ~~o~~mobilishing troops and war equipment has been very significantly.

↳ Railways have help in the mass migration of the population.

(2) social advantages :-

↳ By travelling together in to the compartment without any restiction of cast, the feelings of cast different has disappeared.

↳ The social outlook of ~~the~~ masses has been branded ~~the~~ through railways 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 Advances :-

↳ Mobility of labour has contributed to industrial development.

↳ Growth of inderstries has been promoted due to transPotation of raw materials through railways

↳ Railways provided employment to millions of People so that it helps in solving the unemployment Problem of the country.

↳ Speedly distribution of finished product is achived through railways.

Classification of indian railways.

Classified into 3 categories :-

(1) Trunk route

(2) main line

(3) Branch line

1. Trunk route :—

	Board gauge	Meter gauge
(a) Maxm permissible speed	120 Km/h	80 Kmph
(b) Rail section	50 Kg/m	37.2 Kg/m
(c) Sleeper density	N + 7	N + 7
(d) degree of curvature	7 ½	suitable
(e) Ballast	25 cm below	20 cm below

(2) Main Line :-

	Board gauge	Meter gauge
(a) maxm permissible speed	100 Kmph	75 Kmph
(b) Rail section	52 Kg/m	37.2 Kg/m
(c) Track relaying Period	20 year	30 year
(d) Design speed	120 Kmph	75 Kmph

3. Branch line

	Boardgauge	Meter gauge
(a) maxm 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 year
(d) Design speed	120 Kmph	75 Kmph

Basic 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 train are running at a speed of 16 Kmph or more i.g New Delhi to Howrah.

(b) Group 'B' line :-
It is consist of those route on which the train are running at a speed of ~~100~~ 130 Kmph. ~~or more~~ i.e ~~New~~ Ambala to mughalsarai.

(c) Group 'C' line :-
It consist of sub-urban of mumbai, Kolkata and Delhi.

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

(e) Group 'E' line -
The other route and branch route where the permissible ~~stress~~ speed limit is less than 100 Kmph.

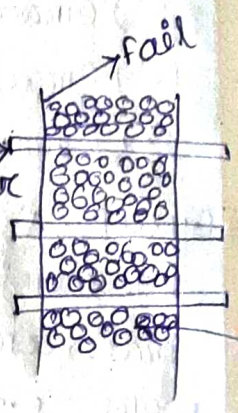
Railway Terminology

1. Rails

Rail are steel girders which provide the hard and smooth surface for moment of wheels of the locomotive and railway vehicles.

(2) Sleepers :-

Sleeper are the members laid transversly under the rail, which are meant to support the rails over them and transfer the load from rails to ballast.



(3) Ballast :-

It is the granular materials packed under and around the sleepers to transfer the load from sleeper to ballast. It helps in providing elasticity to the track.

(4) Boxing :-

The process of filling the Ballast around the sleepers is called boxing of the Ballast.

(5) Broad gauge (BG) :-

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

(6) Metere gauge :- (MG) :-

The distance bet^n running faces of 2 track rails is 1 m.

(7) Narrow Gauge (NG) :-

Gauge of a track in which the distance bet^n running faces of 2 track rails is 0.782 m or 0.61 m.

(8) Gauge :-

In India, It is the min^m distance bet^n the inner running or gauge faces of the two rails.

(9) Embankments :-
The raised structure above the ground level for carrying the railway track is called embankment.

(10) Ballast crib :-
The loose ballast betn the two adjacent sleepers is known as Balast crib.

(11) Adhesion of wheel :-
It is resistance offered by friction betn metal surface of the rail and wheel.

(12) 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 wheel pass over the rails. This arrangment called audible signal or fog signal.

(13) Fish plates :-
It is used to provide continuity betn the 2 rails at the rail joints.

(14) check rails :-
It is provide on the opposite side of the crossing location for guiding one wheel of the vehicles and thus to check the tendency of another wheel to climb over the crossing.

(15) Marshalling yard :-
Yards in which wagons are sorted and new trains are formed called marshalling yard.

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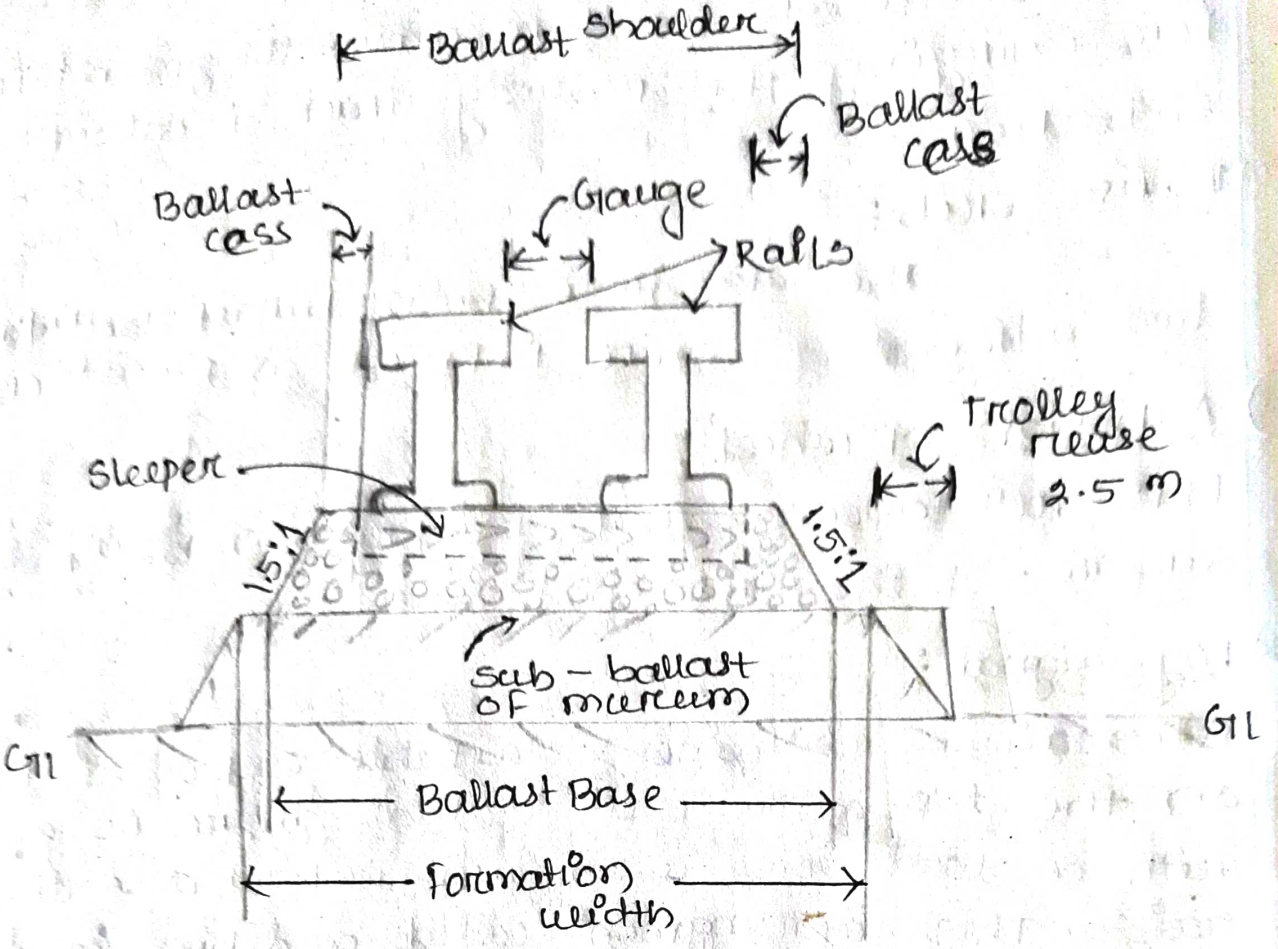
(PERMANENT WAY)



Permanent Way :-

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

↳ In a permanent way the rail are joined in series by fish plates and bolts and then they are fixed to sleepers by different types of ~~fasten~~ fastenings.

↳ The rails act as girders to transmit the wheel load to the sleepers.

↳ The sleeper hold the rail in proper position with the proper tilt, gauge and level and transmit the load from rails to the ballast.

↳ The ballast distribute the load over the formation and hold the sleeper in position.

Component of Permanent way :-

(1) Rails
(2) Sleepers
(3) Ballast
(4) Formation
(5) Gauge
(6) Fitting and fastening

(6) Fastening :-

They provided a connection betn rail and sleeper.

(4) Formation :-

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

Types of Gauge :-

(1) Board gauge (BG) (1.676 m)
(2) Meter gauge (MG) (1 m)
(3) Narrow gauge (NG) (0.76 m) (4) light gauge (LG)
(5) Addete track gauge.

Requirment of an Ideal Permanent Way :-

↳ The gauge should be correct and uniform.
↳ The rail should be proper ~~table~~ level. Two rail must be ~~free from kinks or~~ at the same level.
↳ The aligment should be correct, i.e it should be free from kinks ~~and~~ or irregularities.
↳ The gradient should be uniform and as gentle as possible any change of gradient should be followed by a smooth vertical curve, to give smooth rigiding quality.
↳ The track should be resilient and elastic in order to absorb shocks and vibrations of running track.

↳ The radii and super elivation on curve should be properly designed and ment maintaind.

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

↳ If their is trouble from the creep, the preventionary measures should be to prevent it.

↳ There should be adequate provision for easy renewals and replacements.

↳ The track structure should be strong low in initials cost as well as maitenance cost.

↳ The various component of the track i.e the rail, sleepers, etc mustfully satisfy the requirment for which they have been provided.

↳ Joints, including points and crossings which ~~of the railway~~ are regarded to be weekest points of the railway track, should be properly designed and maintained.

Capacity of a railway track:
It is the hourly capabity of the track to handle the trains safely or in other words it is the no.s of trains that can be run safely on a track per hour.

Suitability of gauge under different condition
There are some condition on which gauge distance depends on

(1) Trafic considaration
(2) Physical features
(3) Development of areas
(4) cost of track
(5) speed of train

(1) Speed of train

For greater gauge higher will be the speed and for higher speed and for higher speed broad gauge.

(2) Traffic condition :-

↳ Volume of trafic, depends upon the size of wagon, speed and hauling capacity of train.

↳ If the intencity of the traffic is more broad gauge track is more acceptable.

(3) Physical features :-

↳ On the sleepers gradient and sharp curve narrow gauge is provided.

↳ In hilly area NG is more reliable or useful

(4) Development of area :-

NG is used to developed thiny populated area by joining the poore developed area with urban areas.

(5) Cost of trait :-

↳ If the sufficients funds are available then board gauge is addoped.

↳ In case sufficient funds are not available then NG is provided.

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TRACK MATERIALS
CHAPTER-3

Rails

- It can be considered as steel gireadors for the Propose of carrying axle load.
- They are made of high carbon steel to withstand weare and tear.

Functions of rail :-

- Rail provided a haired, smooth and unchanging surface for Passage of heavy moving load's with a minm friction betn the steel rail and steel wheels.
- Rails beare the stresses developed due to heavy vertical loads, laterals and breaking forces and thermal stresses.
- The rail materials used that is gives maxm ~~were~~ wear to avoid replacement charges and failures of rails due to wear.
- Rail transmit the loads to sleeper and consequently reduce pressure on ballast and formation below.

Reauirment of rails

- Rail should be proper composition of steel.
- The Vertical stiffneres should be high enough to transmit the load to several sleepers situated below.
- Rail should be capable of with standing lateral face.
- The head must be sufficiently deep to allow for an adequate margin of vertical ~~weae~~ wear The wearing surface should be hard.

↳ The web of rail should be enough so that the rails are stable against overturning specially on curves.

↳ Foot should be wide enough sothat the rails are stable agaist overturning specially on curves.

↳ The tensile strength of the rail piece should not be less than 72 kg/m².

↳ The fillet radii must be large to reduce the concentration of stresses.

↳ The CG of the rail section must be lie maxm tensile and compressive stresses are equal.

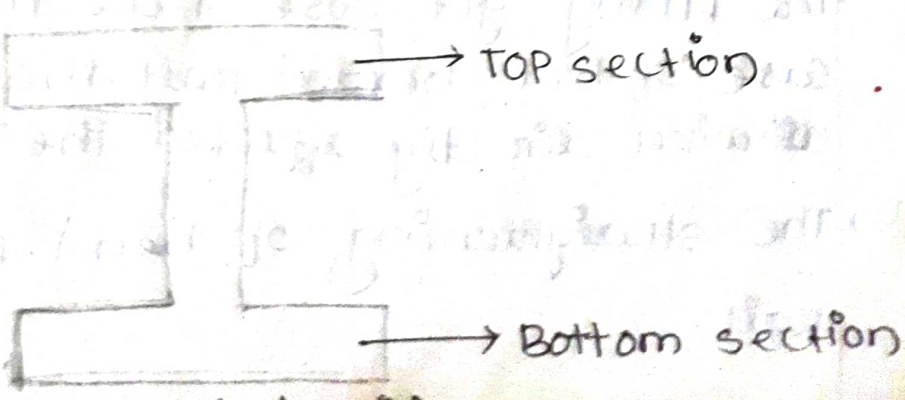
Types of rail section

(i) Double headed rails (DH rails)
(ii) Bull headed rails (BH rails)
(iii) Flat footed rails (FF rails)

(i) Double headed rails :-

↳ Double headed rails are dumb bell originally dumb rail sections were designed in which both the heads were provided with the same cross section.

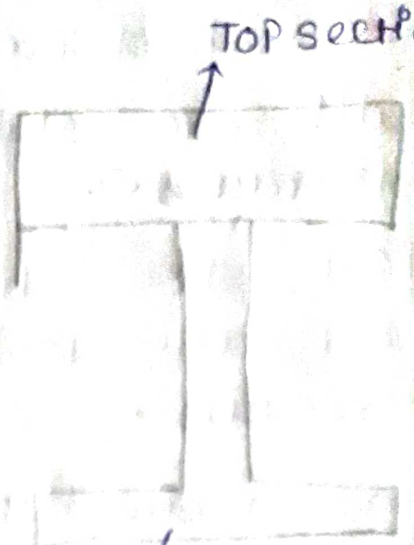
→ The main object in designing such as section was that when the one top section, had worn out due to



(Double headed rail)

(2) Bull headed rail :-

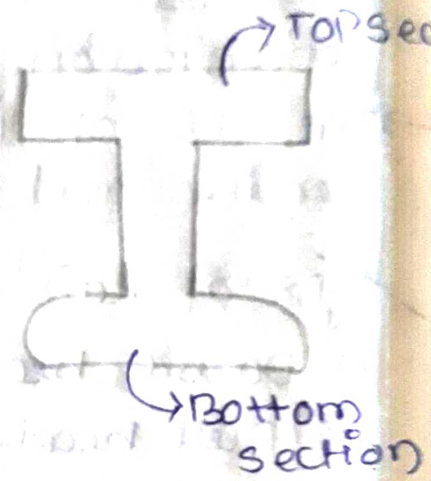
BH rails in which the head was made little thickers and stronger than the lower part by adding more metal to it so that even after wear it can without stresses.



3) Flat footed rail :-

It is also called vignoles rail.

It was observed by heavy train load cause the foot of rails sink into the wooden sleeper.



Merits

↳ They have more strength and ~~suffi~~ stiffness both vertically and laterally, than BH rail.

↳ Fitting of rails with sleepers is simple so they can be easily laid and relaxed.

↳ NO chairs or keys are required.

↳ In points and crossing the arrangement are simplers than bull headed rails.

Demerits :-

↳ The fitting get loose more frequently than in case of bull headed rail the impact of rolling wheel directly affected the fitting.

↳ The straightening of bend rails replacing of rail.

Merit and Demerit of BH rails :-

Merits

→ They keep better alignment and give more solide and smoother track.

→ The rails are easily disconnected from sleeper.

→ The heavy chairs with Larger life to wooden sleeper and greater stability to the track.

Demerits :-

→ They required additional cost of iron chairs.

→ They have loss strength and stiffner.

→ They required heavy maintenance cost.

Length of Rail :-

→ As the weakest ~~Person~~ Portion of the track is the rail joints, hence there are no should be as small as possible.

→ TO reduce the no. of rail joints hence the length of rail ~~joints~~ 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.

→ Standard Length of rail used in indian Railways

For BG = 12.8 m Long rail

For MG = 11.8 m Long rail.

Rail Joints :-

↳ Rail Joints are used to hold together adjoining of a rail in the correct position both in the horizontal and vertical plane.

↳ Rail Joints from the weakest Part of the track.

↳ It is absorbed that strength of a rail Joints is only 50% of the strength of the rails.

Requirment of an Ideal Joints :-

↳ The two rail end should remain true in line both laterally and vertically when train move on the track.

↳ The rail Joints should be as strength and stiff as the rail it self and should be elastic both laterally and horizontally.

↳ The rail Joints should provide ~~the~~ enough space for ~~the~~ free expanssion and contraction to account for the effect of temperature ~~verse~~ variation.

↳ A good Joints should be easily disconnected sothat it can be easily taken out without disturbing whole track for the ~~the~~ Purpose the change of rail or a fish plate.

↳ It should not allow the rail ends to get battered.

↳ The Joint should but fill the above requirement with the minm of initial and maintenanse cost.

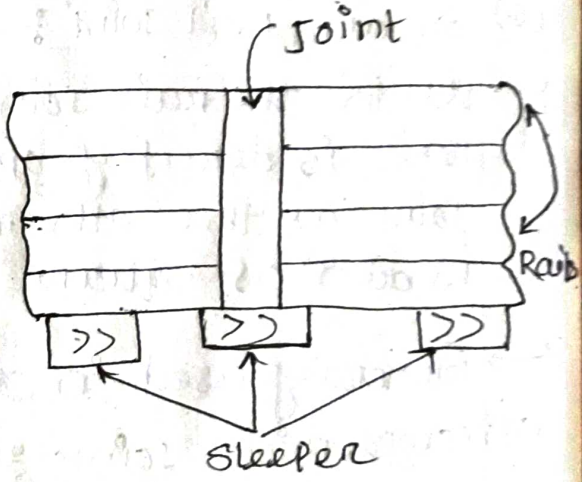
Types of rail Joints :-

10 types of rail Joints

(1) supported rail Joints
(2) suspended rail Joints
(3) Bridge rail Joints
(4) welded rail Joints
(5) staggered or broken rail Joint.
(6) Square or even rail Joint.
(7) Compressive Joint
(8.) Insulated Joint
(9) Base Joint
(10) Exaporsion Joint

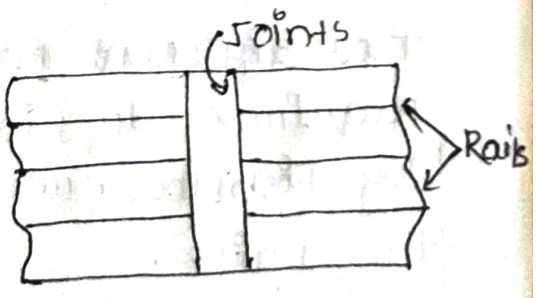
(1) supported rail Joints :-

When the rail end set on a single sleepers is called supported rail Joints.



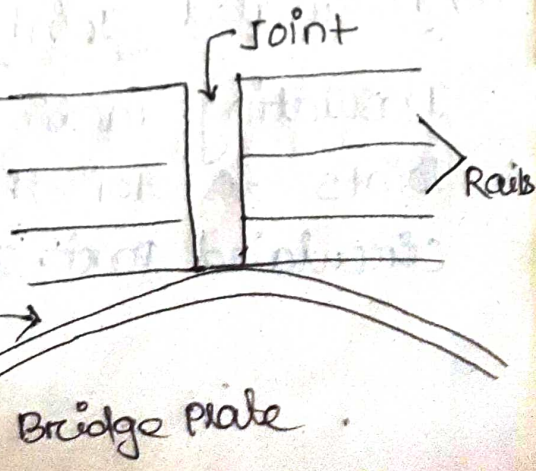
(2) suspended rail Joints :—

When the rail ends projected beyond sleeper is known as suspended rail Joints. used in timber and steel through sleeper. used in indian railways.



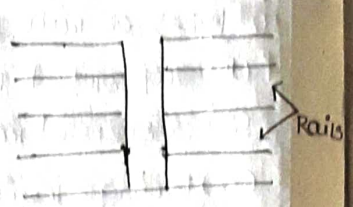
(3) Bridge rail Joint :-

When the rail ends are projected beyond the sleeper and they are carried by flat plane is known as bridge rail Joints. It is not used Indian railway.



(4) Welded rail Joint :-

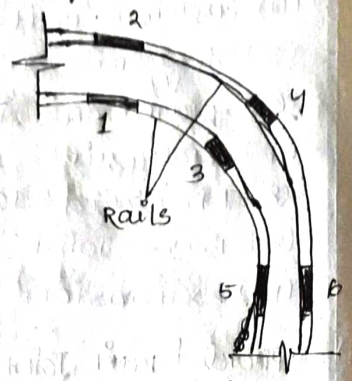
It is a best Joint as they fulfill all requirement of an ideal rail Joint.



(5) staggared or broken rail Joints :-

↳ When the Joints of one rail is not directly opposite to the Joint as the other rail is known as staggared Joint.

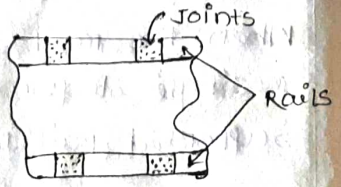
↳ It is usually provided curve.



(6) Square rail Joint :-

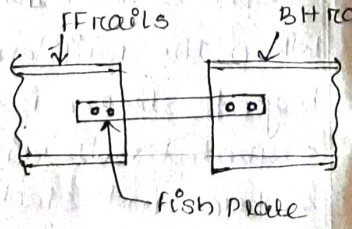
↳ When the rail Joints of one rail is directly opposite to the Joint as the other rail is known as square rail Joint.

↳ Generally used in straight tracks



(7) compermise Joints :-

Two different rail section are required to jointed together, by fishplate which fit both the rails.



(8) Insulated Joints :-

Insulating medium dog is in serted in a rail Joints to stop the flow of current beyond the track circulated part. It is called insulated Joints.

(9) Expansion Joint :-

↳ In bridge provision for expansion and contraction is kept for girders and rail both.

↳ This gap is 2.2 cm for mitred Joint and 1.2 cm for Halved Joint.

(10) Base Joint :-

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

Purpose of welding of rail :-

↳ To reduce the no. of Joints, are requirements of fish plates, which leads to economy and strength.

↳ To repair the worn out or damaged rails and thus increase their life.

↳ To build up worn out points and rails on the sharp curves.

↳ To build up the burent portion of rail head which is caused due to slippage of wheels over the rails or other defects or sports in rail steel.

Advantages of welding Rails :-

↳ It reduce the creep due to increase the length of rail and it turn friction as well.

↳ Expansion effect due to temp is reduced. It also reduced the creep.

↳ It also reduce the maintenance cost of track by about 20% - 40%.

↳ Long rail length beings heavier, dampen the intencity of high frequency vibration due to moving loa

↳ It increases the life of rail due to decrease in wear of rails at joints.

↳ It facilitates track circuiting on the electrified traks.

↳ The cost of track construction by welding of rails decreases due to less no. of rail joints.

↳ It provideds no large bridges for the span length.

↳ Welded rails provisions on curves is under investigation.

↳ Due to discontinuity of joints a source of track weakness is reduced.

Creep:-

It is the longitudinal movement of rail wrt sleepers in a track.

Causes of creep:-

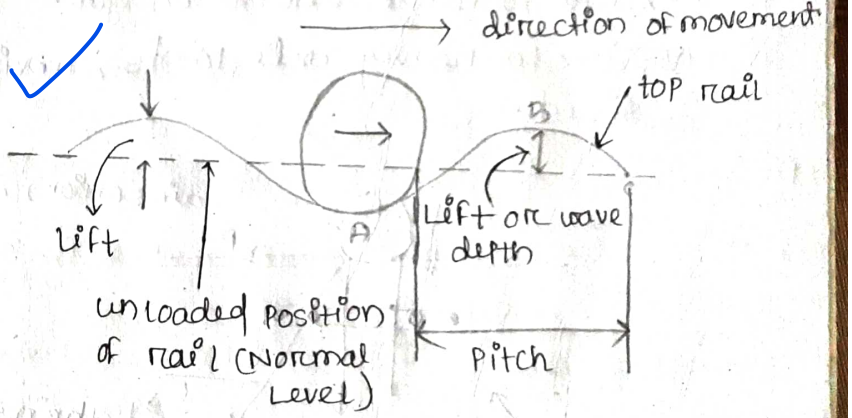
(1) Wave action / wave theory
(2) Percussion theory
(3) Dragging theory
(4) Starting, Accelerating, slowing down or stopping of a train.
(5) Expanssion or contraction of rails due to temp.
(6) unbalanced ~~traffic~~ traffic.

(1) Wave action/ wave theory :-

↳ It is set up by moving loads of wheels.

↳ Vertical reverse curve is formed in rails ahead of wheels the wheels push the wave with a tendency to force the rail in the direction of trafic.

↳ At the wheels is move, the lift in front of the moving load is thus carried forward by the wheels and cause creep, where as the lift at the rear of the wheel gets back to its normal position.



(WAVE THEORY OF CREEP)

↳ Wave action can be reduced by adopting
(i) Angular and heavy ballast which develops
(ii) Increase stiffness of track
(iii) Bigger section of the rail

(2) Percussion theory :-

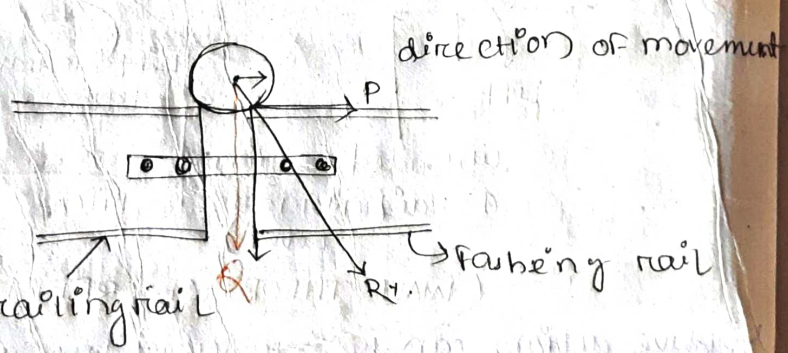
↳ It state that the creep is due to impact of wheels at the rail end ahead at joints.

↳ The horizontal component 'p' of R tends to cause creep while the vertical component tends

Toberds down the rail end vertically i.e to make a battered rail end.

↳ Hence when the wheel level of the trailing rail and strik the facing rail end at each joint, it pushes the rail forward resulting in creep.

↳ Creep by this will increase due to
(i) due to week and loosen fish bolts,
(ii) due to worn out fishplates
(iii) due to loosen packing at joints.
(iv) due to wide expansion gap.
(v) due to heavy axle loads, moving at high speed.



(3) Drag or dragging theory :-

↳ It stress backward thrust on driving wheels of the locomotive of the locomotive of train.

↳ Train has got a tendency to pass the rail off the track backward while the other while of the locomotive.

↳ Vehicles (wheel of coaches and wagons) Pass the rail in the direction of travel as wave theory, so that this creep in the direction of movement of the trains.

(4) Starting, Accelerating, slowing down :-
When a train is starting and or accelerating, the backward thrust of the engine driving wheels tends to pass the rails backward when it is slowing down (i.e decelerating) or coming Push the rail forward.

(5) Expansion or contraction of rails due temp^{c} :-
The creep in this case in influenced by the range in temp variation location of track whether exposed or shady surroundings etc.

(6) unbalanced traffic :-
↳ In a single line system If heavy equal traffic run in both direction, the creep is almost balast.

↳ In the double line system, trains on a particular line being unidirectional creep occurs in both the lines.

Effect of creep :-
↳ Sleepers moves out of square and out of sleepers.

↳ Rail Joints are occur out of three limit in some cases the stresses are setsup in a fish Plate and bolts due to which the bolt some times 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, It becomes difficult to fixit again at proper position by the time gap becomes too short due to creep.

↳ smeeking of fish bolt bending of bars, kinks of joints of rail etc.

Prevension of creep :-

Following are the common methods adopted to prevent creep.

(1) Fitting and fastening of sleeper.
(2) use of proper sleeper size of ballast
(3) Balanced traffic
(4) Increase the weight of rail section.
(5) Regular maintenance of the rail
(6) Welding of joints.
(7) use of anticreeper.
(8) use of steel sleeper.
(9) use of sleepers.

Sleeper

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

↳ Function of sleeper :-

↳ To hold the rail to correct gauge.
↳ To hold the rail in proper level.
↳ To act an elastic medium bet^n the ballast and rail to absorb the blows and vibration of moving loads.
↳ To distribute the load from the rail to the index area of ballast underlying pt.
↳ To support the rails at a proper level in straight tracks and at proper super elevation on curves
↳ sleeper are also add to the longitudinal and lateral stability of the Permanent track on the whole.
↳ sleeper also provide means to rectify track geometry during service life.

Requirement of sleeper :-

↳ The sleeper should be used be economical.
↳ The fitting of the sleeper should be such that they be easily adjusted during maintenance opperation like fitting, packing, removal and replacement.
↳ The weight of sleeper should not be too heavy or expensively light.
↳ Design of sleeper such that gauge, alignment of track and levels of trains can be easily adjusted and maintained.
↳ The bearing area of sleeper should be enough to restic the crushing. (crushing of ballast, rail seat)
↳ The sleeper design, spacing should be facilited easily removal and replacing replacement of ballast.

↳ The sleeper should be capable of resisting shocks and vibrations due to passage of heavy loads.
↳ Sleepers are not damaged during packing processes.
↳ If required, sleepers, should be insulated.
↳ An ideal sleeper should also have an anti-sabotage and antitheft qualities.

Types of sleepers :-
According to materials
(1) Timber or wooden sleeper.
(2) Metal sleeper
It is 2 types
(a) cast iron sleeper
(b) steel sleeper.
(3) concreate sleeper.
(a) Reinforced concrete sleeper
(b) Prestressed concrete sleeper.

(1) Timber sleepers :-
↳ It fulfil almost all the requirements of an ideal sleeper.
↳ Its depends upon their ability to resist.
(1) wear
(2) Decay
(3) Attacks by ants
(4) quality of timbers

Advantages :-
↳ Timber is easily available in all part of india.
↳ It is simple design and fittings are easy.
↳ Timbers sleepers are able to resist the shocks and vibrations due to heavy load moving
↳ It is ~~easily~~ easy to lay, relay, lift and maintain.
↳ It is suitable for all types of ballast.
↳ It is economical.

Dis advantages :-
↳ This sleepers are subjected to wear, decay, attack by white ants, spike killing, warping, cracking, rail cutting etc.
↳ Difficult to maintain the gauge in case of wooden sleeper.
↳ Track are easily disturbed.
↳ Maintenance cost of wooden sleeper is highest as compared to other sleeper.
↳ It have maxm service life (12-15 years)

(2) Metal sleeper :-
↳ Metal sleepers are either in steel or cast iron.
↳ It is economical as compare to wooden sleeper.
↳ Ease in fixation, removals of rails with out disturbing the sleepers.
↳ Ease in pussing out the sleeper. They provide sufficient area of rails i.e area on ballast should be at least equal to that of wooden sleepers.

Advantages :-
↳ It is uniform in strength and durability.
↳ The performance of fittings is better hence lesser creep occures.
↳ It's economical, life long, maintenance is easy

(iii) Gauge can be easily adjusted and maintained in case of metal sleepers.

(iv) For metal sleepers, Frequent renewal is not required.

(v) They have good scrap value, easy in manufacturing and not susceptible to fire hazards.

Disadvantages :-

↳ More ballast is required than orthers types of sleepers.

↳ Fitting required are greater in no. and different to maintain and inspection.

↳ Metals, cast iron or steel are liable to rusting / corrosion.

↳ It ~~becomes~~ beings good conductor of electricity interfreshes with track circuiting.

↳ It is unsuitable for bridges, Level crossing and in case of point s and ~~cr~~ crossings ballast and for rail for which they are manufactured.

(5) Cast-Iron sleeper :-

CI sleeper have been extensively used in India and on a small scale in South America.

Advantages :-

↳ They are easy to manufacture.

↳ Less corrosion.

↳ Higher scarp value

↳ Less liable to crack at rail seats.

Disadvantages :-

↳ Providing less lateral stability

↳ Gauge maintenance is very difficult.

↳ More susceptible to breakage.

(b) steel sleeper :-

In India it is mostly used. This sleeper should ~~be~~ maintain perfect gauge and have sufficient bearing area on the sleeper. It is sufficient heavy for stability and should be strong enough as beams.

Advantages :-

↳ More durable.

↳ It's service life about 50 year.

↳ Easy to maintain gauge and lesser maintenance problem.

↳ It gives lateral rigidity

↳ It is easy to manufacture.

↳ It is not suspectible fire hazard.

↳ It's scarp value is very good.

Disadvantages :-

↳ It is liable to corrosion.

↳ During service its develops crack at rail seat.

↳ It requires more fitting than other.

↳ More ballast is reauire than others types of sleeper.

(3) Concreate sleeper :-

Concrete is an ideal material for the sleeper. used in India and abroad also. It is unaffected by chemical attack of atmospheric gasses, it is

made of strong homogenous grass material.

Advantages :-

(i) It is free from natural decay and attacks by vermin, insects etc.

(ii) service life about 40-60 years in normal condition.

(iii) It is not affected by moisture, chemical action of ballast etc.

(iv) NO difficulty in track-circuiting required for electrify the track.

(v) It have higher elastic modulous and hence can withstand the stress induced by fast and heavy traffic.

(vi) It offers an ideal track in respect to gauge, cross level and alignment, because of elastic fastenings.

Disadvantages :-

(i) scarce values is almost nil.

(ii) Damage of bottom edge during packing.

(iii) weight of concrete sleeper is as high as 2.5 to 3 times of wooden sleeper so it requiring the mecanical appliance for handling.

(iv) It requires plugs for spikes.

(v) The damages to concrete sleepers is very heavy to in case of derailment.

(a) Reinforced concrete sleeper :-

It is 2 types

(i) Through types

(ii) composite or Block and tie types.

(i) Through types :-

In this, when concrete sleeper is stressed, cracks on the tension side is inevitable. Through the crack are very small, it tend to enlarge with repetation of the impact load of the fast trains.

(ii) composite types :-

It is not subjected to some degree of tensile stress. It is not in use, at present. But it gives exceller result in France.

(b) Pre-stressed concrete sleeper.

The concrete is put under a very high initial compression. maxm permissible compressive strength 211 Kg/cm^2. minm cube crushing strenghth of concrete in the sleeper is 422 Kg/cm^2 at 28 days.

Dis advantages :-

(i) Heavily damaged in case of derailment.

(ii) These are uneconomical.

(iii) more rigid in nature.

(iv) Bed of the ballast is specially prepared.

(v) Designed is complicated.

Ballast :-

It is the granular material usually broken stone or brick, kankar, gravel or sand etc. The lateral stability of a track depends on the ballast.

Function of the ballast :-

(i) It transform the load from the sleeper to the subgrade and then distributes it uniformly over a larger area of the formation.

(ii) It hold the sleeper in position and prevents the lateral and longitudinal movement.

(iii) It impart some degree of elasticity to the track.

(iv) It maintain the correct level of the two lines of the track.

(v) It should not produced any chemical action with rail and metal sleepers.

(vi) The material should be easily work

(vii) It provide good drainage immediately below the sleepers and helps to protect the top surface of the formation.

Requirements of the good ballast :-

(i) It should be able to hard packing without disintegrating.

(ii) It should not make the track dusty or muddy and should provide good drainage.

(iii) It should allow for easy drainage with min^m seakage and voids should be large enough to prevent capillary action.

(iv) It should offered resistance to abrasion and weathering.

(v) It should be provide chemical action with rail and metal sleepers.

(vi) The meterials should be easily workable by means of implement in use.

(vii) The Ballast should be available in nearby quarries so that it reduces the cost of supplies supply.

Materials of Ballast :-

(1) Gravels or river pebbles
(2) Broken stone
(3) Ashes or cinders
(4) sand
(5) moorum
(6) kankar
(7) Brick Ballast
(8) Ballast furnace slag.
(9) selected earth.

(1) Broken stone :-

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

↳ The based stone for ballast is non porous hard and angular which does not fray when broken.

↳ Workability is better with smaller size ballast that is 1.9 cm size.

(2) Gravel or river Pebbles or shingle :-
It is attend either from river beds or from gravel pit. It is suitability for use as ballast and it is used in large quantities in many countryies.

(3) Ashes or cinders :-
It is cheap. It is not use for main lines as it is very soft. It is extent drainage properly.

(4) sand :-
It is cheap and provides good drainage. The sand gets into the moving on the track and causes heavy wear.

(5) Moorum :-
It is the soft aggregate used as ballast for sliding and main track when they are newly laid and the embaekment are not sufficiently ~~cost~~ consolidated. It a sliding.

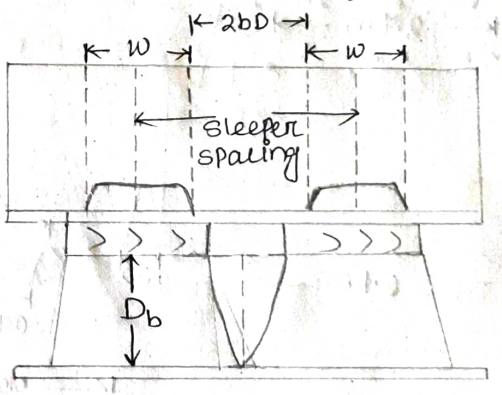
(6) Kankar :-
It is used as road material and us ballast for railway track. It is soft in natere and reduced the Powered undere the roads, used for NG or MG track with light traffic and where better ballast not available

(7) Brick :-
It Powered easily and ~~Powered~~ Produce dusty tracks. Fairly good for drainage over burnt brick and broken bricks are used.

(8) Blast furnace slag :-
It is a by product in manufacture of the pig iron Froms a suitable ballast. It should be hard, high dencity and free from ash holes.

(9) selected earth :-
It is used for formation as temporary measure.

Depth of the Ballast section :-



$$S = 2Db + \frac{w}{2} + \frac{w}{2} = 2Db + w$$

Depth of the ballast = $S - w = 2Db$

$$Db = \frac{S-w}{2}$$

Note :-
Depth of the ballast section will comes betⁿ 20 to 25 cm.

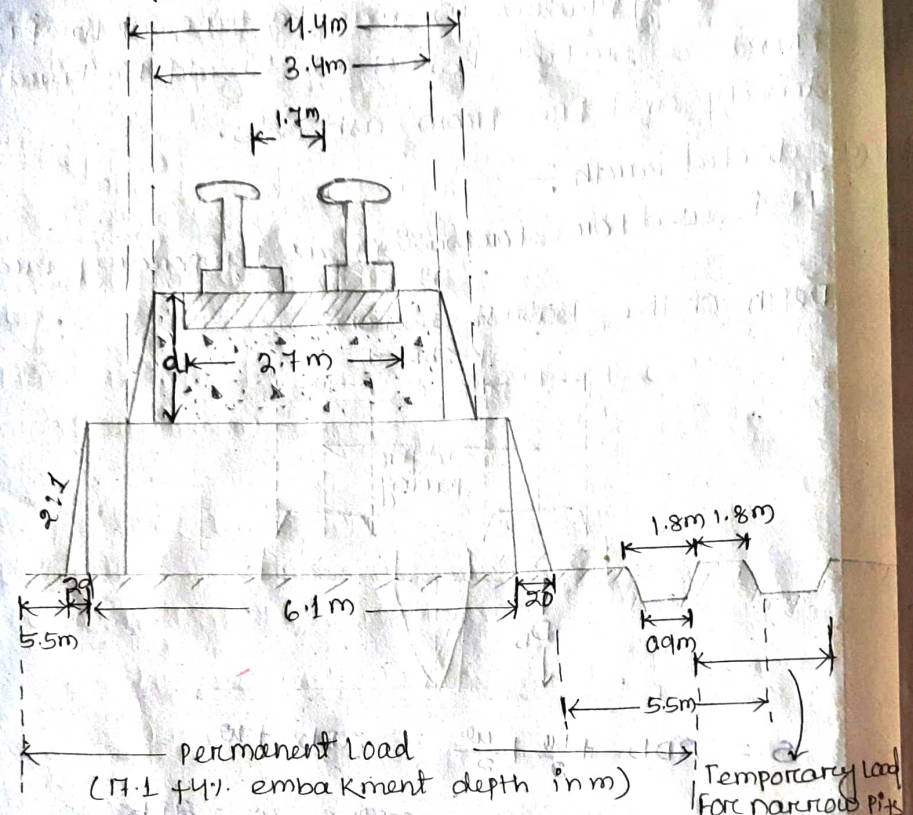
Q. ~~Find~~ the maxᵐ depth of ballast cushion for a BG track of wooden sleeper of having ~~spacing~~ size (275 x 25 x 13) cm width 75cm sleeper spacing.

Ans :- Length (L) = 275cm Breath (b) = 25cm
height (h) = 13cm spacing (S) = 75 cm

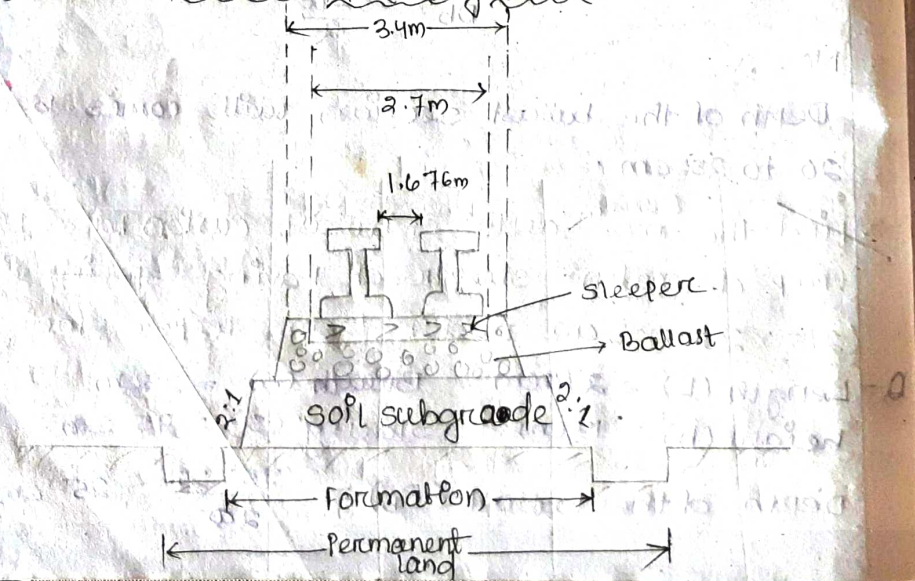
Depth of the ballast (Db) = $\frac{75 \cdot 25}{2}$ = 25 cm.

GEOMETRIC FOR BROAD GAUGE (Chapter - 4)

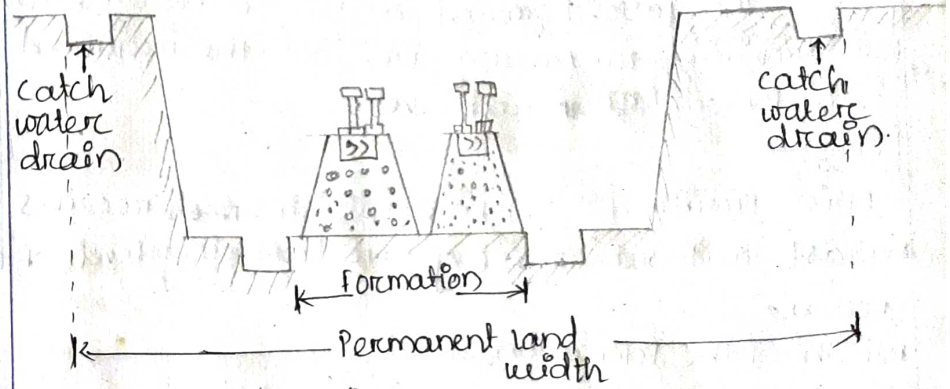
Typical cross-section of BG railway track in embankment



Cross section of BG Railway track



C/S of BG double line in cutting



Permanent track:

It is the track which is of permanent nature and handles the normal comercial traffi for which it is meant. It is also called Permanen way.

Subgrade:

Subgrade is the naturally occuring soil, which is prepared to receive the ballast sleepers and rail for constructing the railway track.

Formation:—

The prepared surface which is ready receive ballast is called formation. The stabi of the track depend upon the quantity of the Formation under it.

Embankment:—

It is the raised bank of earth or other materials constructed above the natural ground.

Cutting:—

The raised ground or hill is cut or excavated for providing the railway line out the required level, below the Ground level.

Level:—

It is prepared surface which ~~rests~~ receives ballast without raising or lowering level of the ground.

Width of the Formation:—

It is the width of the prepared surface to receive ballast. It depend upon

(a) The no of tracks to be laid side by side

(b) The gauge type.

Track Alignment:—

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

Formation width As per indian standards :—

Sl no	Particulars	Dimension in (m) BG	MG	NG	Slop
1.	Embankment width of Bank				
	(a) single line	6.1	4.88	3.70	—
	(b) Double line	10.67	8.53	7.32	2:1
(2)	cutting width of cutting excluding side drains				
	(a) single line	5.49	4.27	3.35	
	(b) double line	10.06	7.93	7.01	1.5:1

Max^m distance bet^n center to center of Tracks:-

Sl no	Particulars	Dimension in (m) BG	MG	NG
1	outside station yards	4.27	3.66	3.51
2.	In side station yards	4.73	(i) Passenger track 4.42 (ii) Goods track 4.27	(i) Passenger track 3.81 (ii) Goods track 4.27
(3)	In tunnels over bridge	4.73	3.96	—

↳ In cutting 1.2m (4') is to be added for the 2 side drains.

↳ slopes of 2:1 are given, on banks while those of cutting are 1:5:1 or sleeper.

↳ The sides are made vertical where solid hard rock exists.

Gradients:—

↳ Any departure of the track from the level is known as grade or gradient.

(or)

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

↳ It is expressed as the ratio of vertical to horizontal.

Neceity of the Gradients:-

↳ To provide a uniform rate of rise or fall as fast as possible

↳ To reach the various stations ~~location~~ located at different elevations.

↳ To reduce the cost of earth work.

Necessity of Gradients :-

Types of Gradients:-

(1) Ruling gradients
(2) momentum gradients
(3) Pusher or helper gradients
(4) Gradients at station yards

(1) Ruling Gradients:-

↳ The ruling gradient on the section may be defind as the gradient which determines the max^m load that the engine can be haul on the section (horizontally)

(or)

↳ It is the max^m gradient allowed on the track section.

↳ As per indian standards.

✓ In Plain terrain, 1 in 150 to 1 in 200.

In hilly regions 1 in 100 to 1 in 150.

↳ The gradient depend upon the additional power of the locomative which shall be able to pull up its train load along the gradient.

Extra Pull = W sinθ = W tanθ
= W gradient

(2) Momentum gradient:-

↳ A train while comming down a falling gradient occur sufficient momentum. This momentum gives additional kinetic to the moving train to overcome a steeper rising gradient then the rulling gradient for a certain Length of the track.

↳ This rising gradient is called as momentum gradient and in such cases a steeper grade then the rulling grade can be adoped.

↳ e.g In vallys, a falling gradient is usually followed by a rising gradient.

(3) Pusher or Helper Gradient :-

The gradient is provided in mountainous region is the grade is concentrated in a specific section such as mountanious section instead of limitting the train load it may be operationally easy to run the train on the basis of load that the engine can carry on the remaining portion of the track and arrange for an pusher engine for the portion where the gradient is severe. such gradients are known as pushers or helper gradient.

(4) Gradient in station yard :-

It have to be sufficiently due to following reasons.

↳ To Prevent the moment of standing vechicle on the track due to the effect of gravity combined with the effect of gravity combined with a strong wide and gentle push.

↳ To prevent additional resistance due to grade on the static vechicle in motion.

AS Per Indian standards:-
Gradient in station yards in 1 in 400 while minm gradient of 1 in 1000 recommened from drainage Point of view.

Grade compensation on curves:-

↳ If a curve lines on a rulling gradient the resistance due to gradient is increased by that due to curvature and further increases the resistance beyond the rulling gradient.

↳ The curve resistance is greater at lower speed.

↳ To avoid resistance beyond the allowable limit the gradient are reduced on curves and this reduction gradient is known as grade compensation on curve.

↳ Curves resistance is expressed as a %. Per degree of the curve.

In India,

	degree of compesation for curve.
For BG	0.04%. Per degree of curve.
For MG	0.03%. Per degree of curve.
For NG	0.02%. Per degree of curve.

↳ Interm of radious of curves in meters.

	degree of compesation for curve
For BG	70/R
For MG	52.5/R
For NG	35/R

↳ Maximum is 75/R.

↳ Grade of compansation = $\frac{30+R}{R}$

Gradient flatter than 4%. there is no grade of compansation.

Q If the rulling gradient is 1 in 150 on the Perticular section of BG and at the same time a curve of 4 degree is situated on this rulling gradient, what should be the allowable rulling gradient.

As per IS
Grade compensation of BG is 0.04%.
Per degree of curve.

Then compensation for 4° curve = 0.04% × 4
= 0.16 %.

Rulling gradient = 1 in 150 = $\frac{1}{150} \times 100$
= 0.67 %.

So, maxm allowable gradient
or
Actual gradient to be Provided = 0.67 − 0.16 = 0.51%.

OR, $\frac{0.51}{100}$ i.e 1 in 196.

(a) What should be the actual rulling gradient?
(a) If the rulling gradient is 1 in 200 on a BG.
(b) A curve of 3° is superimposed on the above track section of BG.

Ans:-

Compensation for 3 curve = 3 × 0.04 = 0.12%.

Rulling gradient is 1 in 200 ie 0.50%.

Actual Rulling gradient = 0.50 − 0.12 = 0.38%.

$\frac{0.38}{100}$ = 1 in 264

Imp Super elevation or cant :-

↳ To counteract the effect of centrifugal force the level of the outer rail is raised above the inner rail by a certain amount. to introduce the centripetal force.

↳ This raised elevation of outer rail above the inner rail at a horizontal curve is called super elevation.

↳ cant should be used to represent the angle of a transverse slop.

↳ It is denoted by 'e'.

Object of providing super elevation :-

↳ To introduce the centrifugal load force for counteracting the effect of the centrifugal force, this will result in the faster moment of train on curves.

↳ It also Prevent derailment and reduce the side wear and creep of rails.

↳ To Provide equal distribution of wheel loads on both rail so that there is no tendency of track to move out of position due to more load on outer rail.

↳ It reduces the weare of rails equipment and results in saving in maintenance cost.

Limits of superelevation :-

According to railway board, max^m super elevation is $\frac{1}{10}$th of gauge.

As Per indian, max^m permissible value of super elevation is given belloco.

(i) For BG = $\frac{1}{10}$ × 1.65 m = 0.165 m = 16.5 cm

(ii) For MG = $\frac{1}{10}$ × 1 m = 0.1 m = 10 cm

(iii) For NG = $\frac{1}{10}$ × 0.76 m = 0.076 m = 7.6 m.

Imp Cant Deficiency :-

↳ The equilibrium cant is provided on basis of equilibrium speed. But this equilibrium cant fall short of that required For the high speed trains. This shortage of cant is called "cant Deficiency".

C_q = e − Actual cant

↳ It is limited due to two reason.

↳ higher cant deficienty gives rise to higher discomfort to passenger.

↳ Higher cant deficiency means higher would be the balanced centrifugal forces and hence extra pressure and lateral forces on outer rails. This will required strong track and fastening for stability.

Negetive super elevation :-

It is different bet^n actual cant provided and theoretically cant required for such lower speed.

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

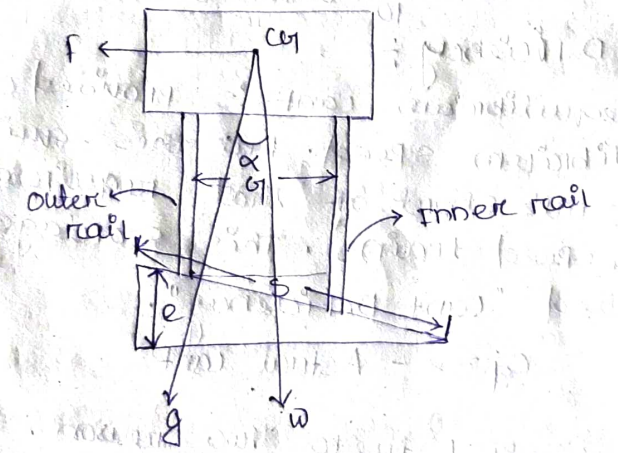
Relationship bet^n of e, G, V, R

e = super elevation

G = Gauge

v = speed

R = Radius of curve



W = weight of moving vehicle in Kg

v = speed of vehicles in m/sec

V = speed of vehicles in Km/h.

R = Radious of curve in m.

G = gauge of track in m.

g = acceleration due to gravity in m/sec².

α = angle of inclination.

S = Length of inclined surface in m.

Centrifugal force (F) = $\frac{Wv^2}{gR}$ —①

Now resolving the forces along the inclined surface we get.

$F\cos\alpha$ (horizontal) $= W\sin\alpha$ (vertical) —②

$F = \frac{Wv^2}{gR}$, $\cos\alpha = \frac{G}{S}$

$\sin\alpha = \frac{e}{S}$

$\cos\alpha = \frac{G}{S}$

eqn ② becomes

$F\cos\alpha = W\sin\alpha$

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

$e = \frac{v^2}{gR} \times G$ (in meters) —③

$\therefore e = \frac{Gv^2}{gR}$ here v in m/sec.

TO * TO convert in Kmph

$e = \frac{G(0.278V)^2}{9.81} = \frac{GV^2}{127R}$ m

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

where, G is in m.

R is in m

V is in Kmph

In India,

For BG , G = 1.676m

$e = \frac{GV^2}{1.27R} = \frac{1.676V^2}{1.27R} = 1.$

similarly

For mG , G = 1m.

$e = 0.80\frac{V^2}{R}$ cm

For NG , G = 0.762 m

$$e = 0.60 \frac{V^2}{R} \text{ cm}$$

When the lateral force and wheel load are almost equal, the cant is said to be equilibrium. This equilibrium cant is provided on the basis of Average speed of train.

If a 8° curve track diverges from a main curve of 5° in an opposite direction in the layout of a BG yard, calculate the super elevation and speed on the branch line. If the max^m speed permitted on the main line is 45 Kmph.

Soln.

(i) For BG, G = 1.676 m D = 5°

V = 45 Kmph

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

$$R = \frac{1720}{5} \qquad D = \frac{1720}{R} \Rightarrow R = \frac{1720}{D}$$

$$e = \frac{1.676 \times 45^2}{1.27} \times \frac{5}{1720} = 7.78 \text{ cm}$$

(ii) For BG, the cant deficiency ~~from~~ for main line = 7.6 cm, permitted

(iii) So the cant for main track = 7.78 − 7.6 = 0.18 cm

(iv) Cant to be provided for branch track = −0.18 cm

i.e negative cant.

(v) For cant deficiency 7.6 − 0.18 = 7.42 cm

V = ?

$$e = \frac{GV^2}{1.27R}$$ for 8° curve, V = ?

$$7.42 = \frac{1.676 \times V^2}{1.27} \times \frac{8}{1720}$$

$$V^2 = \frac{7.42 \times 1.27 \times 1720}{8 \times 1.676}$$

V = 34.7 Kmph ≈ 34 KMPH.

(vi) A 5° curve diverges from a 3° main curve in reverse direction in the layout of a BG yard. If the speed on the branch line is restricted to 35 Kmph, determine the restricted speed on the main line.

Soln,

For BG G = 1.676 m

D = 5°

V = 35 Kmph

$$R = \frac{1720}{5^\circ}$$

$$e = \frac{GV^2}{1.27R} = \frac{1.676 \times 35^2}{1.27 \times \frac{1720}{5}}$$

$$= \frac{1.676 \times 35^2}{1.27} \times \frac{5}{1720}$$

$$= 4.69 \text{ cm}$$

BG · cant deficiency main line = 7.6 m

So, cant for main track = 4.69 − 7.6 = −2.89 m

(negevite cant = max^m permisible super elevation on the mainline)

Theoritical super elevation which can be provided on main line = 2.81 + 7.6 = 10.49

$e = 10.49$ $D = 3^\circ$

$$e = \frac{GV^2}{1.27R} \quad \text{or} \quad 10.49 = \frac{1.27 \times 1726}{1.676 \times 3}$$

$$V^2 = 4557.35$$

$$V = 67.50 \text{ kmph.}$$

Q. What is the equilibrium cant on a 2° curve on a BG if 15 train, 10 trains, 5 trains and 2 trains are running at a speed of 50 kmph, 60 kmph, 70 kmph and 80 kmph respectively.

CH-5

(POINTS and CROSSING)

Defination:—

Points and crossing are specially arrangment on the track to facilited smooth division of train from one track to another. It is also help for marshalling and shunting work in station yards.

Nececity:—

↳ Point and crossing provided flexibility of movement by connecting one line to another according to requirment.

↳ They also help for imposing restriction over turnouts which necessarily retard the movement.

↳ From safety aspect, it is also important as point and crossing are weak kinks or points in the track and vechicles are suspectable to dercailment at these places.

Turnouts

↳ It is the simplest combination of points and crossing which enables one track either a branch line or a sliding, to take off from another track.

↳ It is provide to facilities for safe moment of train in either direction on both the track.

↳ Parts of turnouts:-

(a) A pair of points or switches (ABCD & EFPQ)

(b) A pair of stock rails.

(c) A vee crossing (GHIJ)

(d) Two check rails.

(e) Fourc ~~rail~~ load rails

(f) Swich tie-plates or 'gauge tie chairs' and crossing tie-plate.

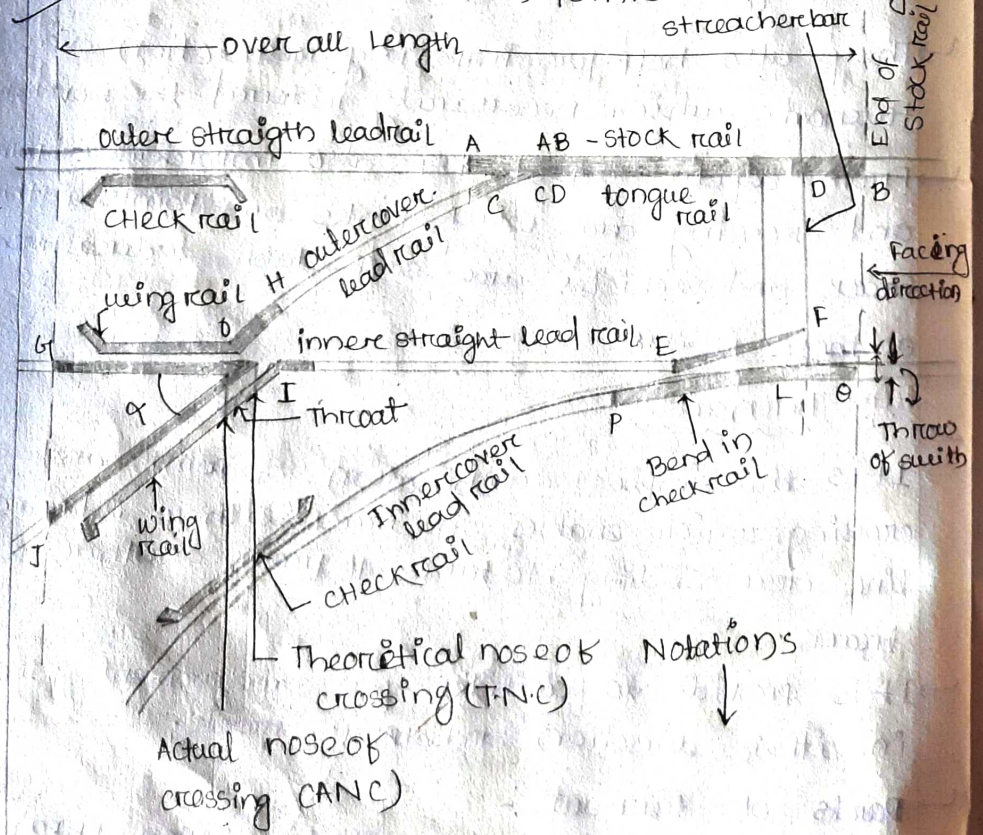
(g) studs, or stops.

(h) Bearing plates, slides chairs, stretchers bars etc.

(i) For operating the points - Rods, cranks, leavers etc.

(j) For locking system - locking bore, lock bars, Plungers bars etc.

Important Terms used in points and crossing:-



Notations

{ Left hand turnout } (Split switch)

(i) Face Direction:-

If someone stands at the tol of switch and looks towards the crossing then the direction is called facing direction.

(ii) Trailing direction:-

If someone stands at the crossing and looks towards the switches, then the direction is called traing direction.

(iii) Face Points of turnout:-

Where train pass over the switches first and they pass over the crossing is called face point of turnout.

(iv) Trailing Point of Turnouts:-

Where train moves inthe opposite site of facing point inwhich the train pass over the crossing first and then over the switches is called trailing point of turn out.

(v) Right hand Turn out:-

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

(vi) Left hand turn out:-

If a train from main track is divided to the left of the main route in the facing direction this diversion is known as left hand turnout.

(vii) Right-hand and left-hand switches :-

It is depend upon left to right when seen from the facing direction i.e stand at point and 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 rail lies bet the 2 stock rail and these are to a point or toongue of 0.64 cm to 0.95cm wide.

(xi) Stretcher bar :-

The toes of both the tongue rail are connected together by means of stretcher bar

(xii) Distance block :-

This blocks are inserted bet the heel of the tongue rail and stock rail.

Types of switches :-

A turnout works with the combination of points and crossing. The s consist of mainly a pair of points and of switches.

Two types of switches

(1) stub switch

(2) split switch.

(1) Stub switch :-

↳ In stub switch, no separate tongue rail is provided and some person of the track is moved from side to side.

↳ It is an old form of the switch.

↳ It is no more in use and has be replaced by the split which is universally adopted.

(2) split switch :-

↳ In this types of switch a tongue rail is combined with the stock rail.

↳ on the basis of fixation at heel split switch classified as.

(a) Loosed heel types

(b) Fixed heel types

(c) under cut switches

(d) Straight cut switches.

Crossing

A 'crossing' or a 'frog' is a device which provided two flange ways through which the wheels of the flange may move, when two rails intersects each other at an angle.

Component parts of crossing :-

(1) A crossing or vee piece.
(2) Point and splice rail
(3) wing rails
(4) check rails
(5) Chair at crossing at toe and at heel.
(6) Blocks at throat, at heel and distance block.
(7) In some cases, packing below the wing rails at toe and throat.

Requirements and charcateristics of good crossing:-

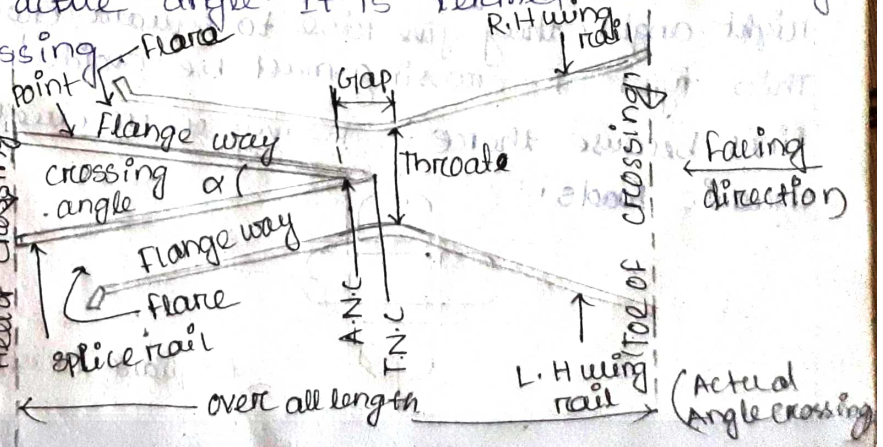
(i) The assembly of a crossing has to be rigid to stand against severe vibration which causes loosing of the component.
(ii) The wear on the parts of the wing rails, opposite the nose and also of nose itself must be protected. It is achived by use of special steel.
(iii) The nose of crossing should have some thickness from pratical considerations.
(iv) The crossing body should be as rigid as possible and as long as practicable.

Types of crossing :-

(a) On the basis of shape of crossing
   (1) Acute angle or 'V' crossing
   (2) obtuse angle or crossing or diamond crossing.
   (3) Square crossing
(b) On the basis of Assembly of crossing.
   (1) Spring or movable wing crossing
   (2) Ramped crossing.

(A) (1) Acute angle or 'V' crossing :-

It is widely used. This crossing obtained when a left hand rail of one track crosses a right-hand rail of another track or vice versa. If the angle of intersection of the approching rails is acute angle. It is termed as Acute Angle crossing.

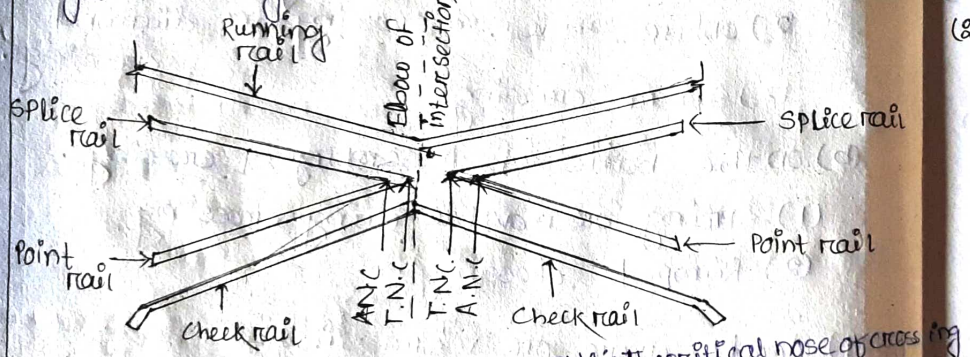


(A) (2) Obtuse angle crossing :-

This crossing is obtained when left-hand rail of one track crosses right-hand rail of another track or vice versa at an obtuse angle.

A diamond crossing, a pair of special crossing is used which is called "obtuse crossing".

In case of obtuse angle crossing the long wings rails donot carrcry the wheels as in case of acute angle crossing, rathere act as cheeked rail.

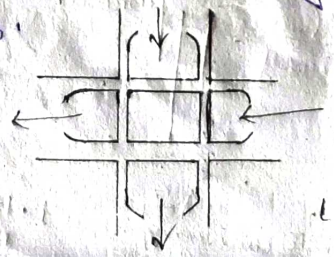


TNC :- Theoritical nose of crossing
ANC - Actual nose of crossing

(Obtuse angle crossing)

(A-3) Square crossing :-

When two straight tracks cross each other at right angles, they give rise to square crossing. This types of crossing must be avoided on main lines because there is heavy weare due to dynamic loads.



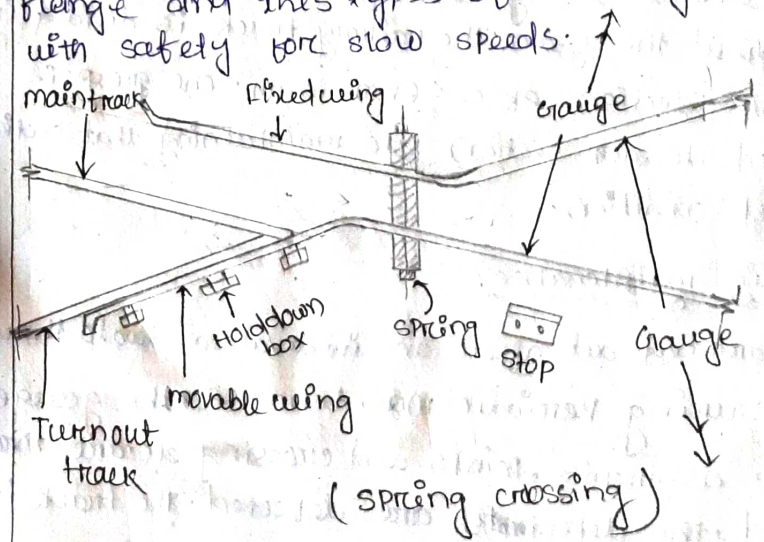
(Square crossing)

(B) (1) Spring or movable crossing :-

In such a crossing, one wing rail is movable and is held against the vee of the crossing with a strong helical spring. By this, it makes the main track continuous and this becomes very useful when there is high speed traffic on the branch line or a turn out. It is used in USA, But it is not favoured in India because there is a dangere of accident in case of spring failure.

(2) Ramped crossing :-

In case of complicated yard layout with heavy but slow traffic, the throat to nose clearance is negotiated by use of special manganese steel blocks over long distance. The wheel flanges roll over this distance extending from a little beyond the throat to little beyond the nose, so the entire wheel load comes on the flange and this types of crossing may be used with safety for slow speeds.



(Spring crossing)

Method of maintenance of track :-

The maintenance of railway track can be carried out either manually or by use of mechanical appliances or by combination of both i.e machines and labour.

In India, conventional maintenance is carried out by means of manual labour and hand tools.

In America and other developed countries mechanical appliances as largely used.

Maintenance of track can be divided in to 2 part :-

(a) Daily maintenance
(b) Periodic maintenance

(a) Daily maintenance :-

It is carried out by the full time staff maintained throughout the year. The railway track is divided in suitable sections of 5 - 6km length. one group is attached to each section for maintaining that section is good condition.

(b) Periodic maintenance :-

It is carried out after an interval of two to three year. During Periodic maintenance, the gauge, levels, alignments, points and crossing etc. are thoroughly checked, the defects are detected. The track is made in Perfect condition by renewing all its major and minor defects. The subject of maintenance is very wide. The maintenance of track includes the following item :-

(1) surface of rails
(2) Track alignment
(3) Gauge
(4) Proper drainage
(5) Track component
(6) Bridges and its approaches
(7) Rolling stock
(8) Point and cross
(9) Level crossing
(10) Tunnels

Duties of a permanent way Inspector (PWI)

Duties of PWI can be divided into three heads

(a) Duties in the field work
(b) Duties in the office work.
(c) miscellaneous duties.

(a) Duties in the field work

(i) The PWI is personally responsible for maintaining the track in a safe condition for passage of trains.

(ii) He inspects the track of his section at least 2 to 3 times in a weeks. notes down the defects by using different symbols and rectifies them.

(iii) He inspects track by push trolly or by travelling on an engine or a brake van.

(iv) He keeps all the records of programmes or work renewalls, Progress of maintenance work and relay of track.

(v) He imparts instruction to Gangmate or group, Keyman, Gateman at level crossing and Assistant PWI.

(vi) At the time of accidents, he should make the track safe in shortest possible time and should make enquires for the causes of accidents.

(b) Duties in office work :-

→ He takes care of the labours and materials and also maintains the accounts of gangman, keyman as well as materials.

→ He controls the workshops such as smithy, Carpentry, welding etc.

→ He prepares the estimates of the maintenance work and makes report of works.

(c) Miscellaneous Duties :-

(i) He attends, all the monthly meetings of PWI, usually at Divisional Engineers offices.

(ii) He has to attends the inspection if made by Divisional Engineering or Assistant Engineer etc.

(iii) He also attends the inspection of govt Inspector fore Railways (GIR) with all the relevant drawing and reports of work.

(BRIDGE)

Introduction :-

↳ It is an communication route provided there is any obstraction to the traffic.

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

↳ The required passage may be for a railway track road way.

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

component of bridge :-

The bridge structure can be devided into 2 part :-

(i) super structure
(ii) sub structure of foundation.

(i) super structure :-

It is that part of a bridge over which the traffic move safely. It consist of parapet, roadway girder, Arches, trusses over which the road is support.

(ii) Sub-structural of foundation :-

↳ The fuction of structure is similare to the function of foundation provided in the building thus the sub structure support the super structure and distribute the load to the super structure.

↳ The substructure consist of foundation, pairs, abutment, wingwell approaches they all support the super structure of the bridge.

classification of bridge :-

Bridge can be classified into various types depending open the following factor.

(i) classification according to material wise.
  (a) Timber bridge
  (b) steel bridge
  (c) R.C.C bridge
  (d) Massonary bridge
  (e) composite bridge

(ii) classification ~~along to~~ according to alignment of Bridge :-
  (a) Straight bridge
  (b) skew bridge

(iii) According to location of bridge floor :-
  (a) Deck bridge
  (b) semi through or through bridge.

(iv) According to perpose :-
  (a) Highway bridge
  (b) Railway bridge
  (c) foot bridge.

(v) According to nature of super structure :-
  (a) portal frame bridge
  (b) Truss bridge.
  (c) Balance 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 fix ore movable bridge :-
  (a) Permanent bridge.
  (b) Temporary bridge.
  (c) Lift bridge.

(ix) According to span of bridge :-
  (a) culvert bridge (span less than 6m).
  (b) minor bridge (span bet^n 6 to 30m)
  (c) major bridge (span more than 30 m)
  (d) long span bridge (span more than 120 m)

(x) According to types of connection :-
  (a) Pin-connected bridge
  (b) Riveted connected bridge.
  (c) welded bridge.

Section of bridge side :-

→ The section of side to bridge is done considering the economy and safety.

→ The place of side is determine by the position of road or railway or mainly there are 2 possible crossing of the road or railways line over a river.

(a) simple right angle streem crossing.

(b) Streem crossing on skew angle.

→ But if the position of railway line or road aligment does not influence the side the following factorres governed.

Selection for the ideal site for the bridge :-

→ Straight reach of the streem.
→ well defined fire bank.
→ Streem line flow.
→ minimum width and right angle crossing.
→ Farm foundation.
→ Availability of construction materials.
→ Labour.

(a) Straight reach of the stream :-

Both the upstream and down streem side of the river should be straight because this will ensure smooth and uniform flow.

(b) well define fire bank :-

→ All the site of the bridge both sides banks should be Permanent and high.
→ The site bank should be free form erosion, collapose by Impact of water in high wind and flood.

(c) Streem line flow :-

At the site of the bridge both sides the riverr should have streem line flow because turbulent flow causes scouree in the bed.

(d) minimum width and right angle crossing :-

This means a clipest bridge when ever possible small streem may be diverted to cross a right angle Instread of skew angle.

(e) From foundition :-

The natere of soil in the bed most provide good foundation

(f) Availability of construction materials :-

The situation of bridge should be such that plenty of good hard and durable materials are for the construction of bridge are available neare the site.

(g) Labour :-

A site where labourcres for the construction of bridge are available.

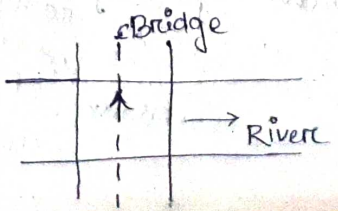
Bridge aligment :-

Depending upon the angle which is bridge makes with the outs of the riverr the aligment can be of two types :-

(i) square alignment
(ii) skew alignment

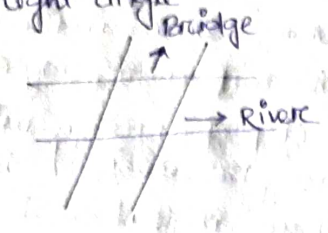
(i) Square aligment :-

In this bridge is act right angle to the axis of the river.



(ii) Skew alignment:-

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



(iii) water way:-

The area through which the water flows under the bridge super structure is known as water way of the bridge

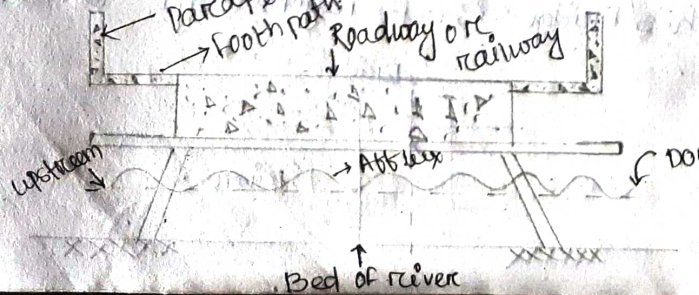
Afflux:-

↳ The rise in water level of the river, neare the bridge is less than the natural width of the river immidiatly of the upstream

Afflux:-

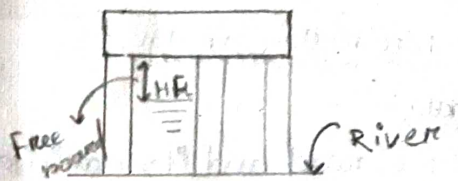
↳ The rise in water level of the river, near the bridge due to obstruction created by the construction of abutment and Pierre is called afflux.

↳ When the effective lineare water way of abridge is less than the natural width of the river immidiatly of the upstream side of the bridge afflux is created



Free board:-

↳ It is the vertical differance bet the design high flood level allowing for afflux and the lowest part of the bridge structure.



↳ Free board is provided for passing floating parts, Fallen trees, Traeks, boats etc from one side of the bridge to the other side.

Types of Bridge	Free board
1. Arch Bridge	300 MM
2. High Lavel Bridge	600 mm
3. Girder Bridge	600mm to 1000mm
4. Navigation streem bridge	2500 to 3000 mm

Economic span:-

↳ Economic span of abridge 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 metercial and its Nature
(ii) Availability of skilled labaer.
(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 engineering incharge of the investigation should carry out study regarding ings in financial, economical, social and physical Feasibility

(1) Design data for major Bridge :-

(a) General data :-

(i) Name of the road and its classification

(ii) Name of the stream

(iii) Location of benchmark and its reduce level.

(iv) existing arrangment for crossing the stream.

* During monsoon

* During dry season

(v) Liability of the site to earth quake.

(2) catchment area of runoff data :-

(i) catchment area

(a) In hilly Part

(b) In Plane area.

(ii) minimum rainfall intencity

(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 Perenial or seasonal.

(ii) River banks at the proposed side can be

* Firm and

* Firm

(iii) ordinary flood level.

(iv) surface velocity of LWL (Low water Level)

(v) Bed slop at the LWL

(vi) Bed Bearing capacity of soil

(vii) check erosion.

(4) Data regarding allgment and approaches :-

↳ The purposed allgment of the brigdge can be skew and square.

↳ In case of curve approaches the purpose roddi of the curve is determine.

↳ The Purposed gradient in approaches are determined

(5) super structure data :-

↳ Proposed clear roadway overe the bridge.

↳ Proposed width of footPath.

↳ camber or road Formaskion.

↳ The proposed bridge can be design to pass maximum flood.

↳ ordinary flood or only dry season discharge.

(6) Sub structure or foundation data :-

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

(7) Data or existing structure :-

↳ Position of existing bridge upon index plan.

↳ Details of existing bridge.

(a) size and no's of span

(b) Types of sub structure.

(c) Types of supere structure.

(d) Types of depth of foundation.

(8) Miscellaneous data :-

↳ Name of the inhabidate locality.

↳ Facility available for comodation and sight fore constreetion staff.

→ Nearest railway station and it distance from site.

means of transpare for materials.

↳ Availabity unskilled and skilled labour for diff tread requirement for construction.

↳ Availabity of electricity.

↳ Nearest place of availabity of cement, steel and timber.

↳ Availability of quantity of stone from the nearest quarries.. for stone masonary work.

↳ 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 and sub structure.
(i) Elevation, section and plan of bridge

↳ The Physical properties of the soil required of the bridge size is very essential for correctly deciding the location and types of foundation.

↳ The complete subsurface investigation can be done as follows.

(i) Measure of the soil deposite upto uptothe sufficient hight.
(ii) Depth, thickness and compitition of soil ~~stat~~ stratas
(iii) The location of ground water.
(iv) depth of the rock.

(v) The engineering properties of soil.

(a) In exploration programme the extend of distribution of different soil both in the horizontal and vertical direction can be determine by the following method.

1. By use of open pot.
2. By making bore hole.
3. By sounding
4. By geophysical method.

— × —

Scour depth :- When the velocity of the stream excluding the limiting velocity scour occur the normal scour depth of the water in the middle of the stream.

Depth of foundation :-

The depth of the Bridge foundation is determine by considaration of the same bearing capacity of soil after taking in accure the effect of sourice.

The min^m 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 foundation

P = Bearing capacity of soil i.e kg/m²

w = specific weight in kg/m²

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) caision foundation.

Spread foundation :-

This types of foundation is shape is similare as provided for walls. It provided in such situation where the scouring of the river bed is min^m. This types of foundation can be as provided even if the bed contain sand but scouring is provided by driving piles the minimum depth of this foundation. is

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

h = height of the foundation

P = Bearing capacity of soil i.e kg/m²

w = weight in specific in kg/m²

ϕ = Angle of internal friction of the soil.

(ii) Pile foundation :-

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

Pile foundation maybe defind as a column support a foundation is cast in situ or Precast. This types of construction is addopted when the loose soil extends to great depth.

(a) Pile driving :-

A process of forceing a pile into the ground is known as pile driving. The equipment required for pile driving are for frame, pile hammer, lead, winches.

(b) Pile frame :-

Pile frame are generally made of steel having high verm bet^n 10 - 25 m.

(c) Pile hammer :-

The hammer is guided bet^n to parallel steel member known as lead. Hammer are of following types.

(i) Drop hammer
(ii) single acting steelehammer.
(iii) Double acting steelehammer.
(iv) Differentiate acting steel hammer.
(v) vibratory hammer
(vi) Disel hammer.

(i) Drop hammer :-

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

(ii) single acting steamhammer :-

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

(ii) Double acting streem hammer

In this types ~~of~~ the hammer is raised and lower either by stream or compressed aer the height of double acting steam hammer is about 500kg but together with steeam pressure. It has an effect of a weight about 3 ton the numbers of blows per minutes is about 100 to 200.

(iv) Differentiate acting steam hammer :-

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

(v) Disel hammer :-

The disel hammer is a small light weight self containt and self activing pipe using gasaline fore fuel.

(vi) Vibratory hammer :-

In this types the driving unit vibrate at high frequency.

(vii) Lead :-

They are employed to guide the hammer and pipe.

winches :- These are required to level the hammer and pipe.

coffer dam :- It is the temporary structure which is constructered so as to remove water or soil from an area and make it possible to carrey on the construction work. under reasonabely dry condition

Requirment :-

↳ constructed at sight work.
↳ It should be water tight.
↳ Absolute water tightness is 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 max^m water level and other destructive force to make it stable against bursting.

↳ Materials used can be timber, steel, soil, concrete

↳ Types of construction depend on depth, soil condition, materials etc.

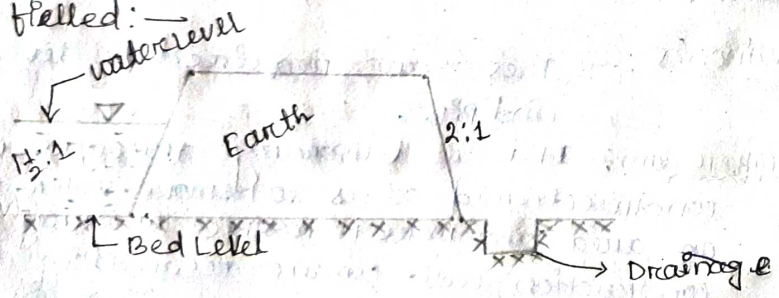
↳ Water excluded by coffer dam can be ground water deep or running water etc.

Types of coffer dams:—

There are six types of coffer dams used for bridge construction.

(i) Earth filled
(ii) Rock filled
(iii) Rock filled crib
(iv) single wall
(v) Double wall
(vi) cellular

(i) Earth filled:—



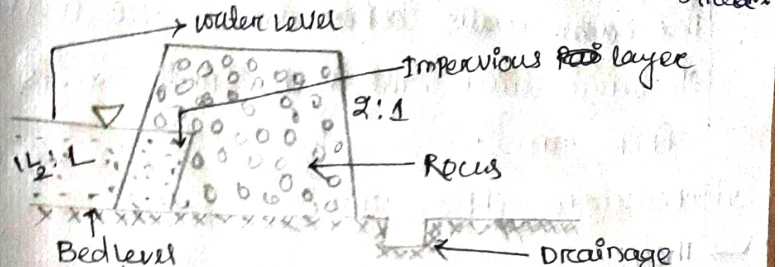
↳ This is the simplest form of cofferdams its use is limited.

↳ It should never be used where their is danger of over topping by water.

(ii) Rock Filled:-

↳ A rock filled crib cofferdam is comprised of timber cribs a crib is a frame work of wooden horizontal

Rock Filled:- They are constructed by placing rock along stream

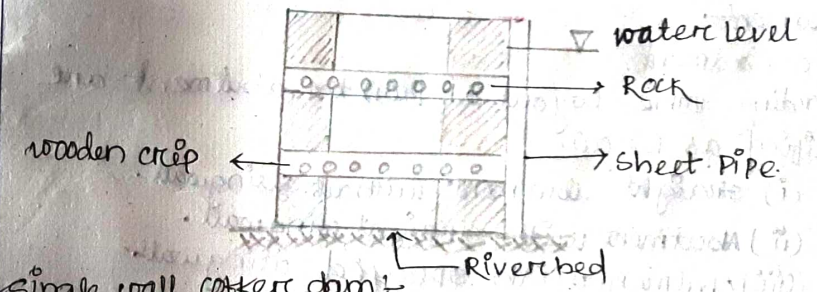


They can be used for a depth of water upto 3mt. They are economical in places where rock is available in plenty.

↳ An impervious layer of earth is laid on the outer face of the coffer dam.

(iii) Rock filled crib:-

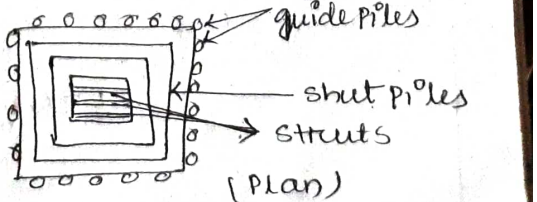
A rock filled crib cofferdam is comprised of timber cribs a crib is a frame work of wooden horizontal and cross beams laids alternate caires.



single wall cofferdam:-

↳ This type of cofferdams is suitable when available waming space is limited and area to be enclosed is small.

↳ It may use upto max^m depth of water of 25mt the walles of the cofferdams are normally made of steel sheet piles.



(v) Double wall :-

The double walls coffere dams are provided to enclosed of large area. The double walls gives stability to the coffer dams.

(vii) cellular coffere dams :-

↳ They

ABUTMENT :-

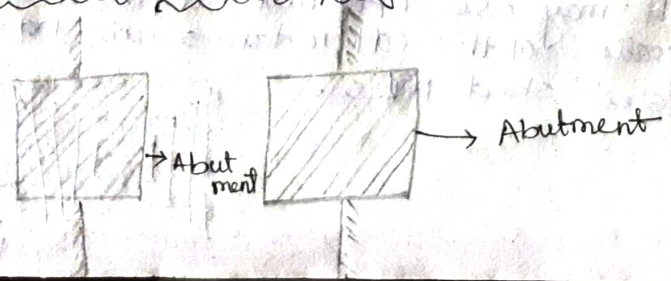
The end support of a super structure is called abutment.

Types of abutment :-

According to the layout of plan the abutment are classified as below.

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

(i) straight abutment without wing wall :-



↳ This types of abutment are not generally adopted on water ways. As the flood will penetrate through the joined of masonary into the earth.

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

(ii) Abutment with straigh wingwall :-

↳ This types of abutment are also not suitable for water way as the water immidiatly behind the wingwall and damage the embaukment.

(iii) Abutment with splayed wing wall :-

↳ This wing wall are made straight but they are splayed at angle 45° and 30° with the face of abutment

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

(iv) Tee abutment:-

↳ This types 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 wingwall are runback into the fill.

↳ The wing walls are parallel are to the road way. This types of abutment are suitabbely where rock stay make in setup the wing wall footing.

↳ The abutment with return wingwall are also known as V-abutment. In this types of abutment is extended at right angle at both the end to same distance to protect thus earth work.

↳ These are used where banks are stiff and rock.

(vi) Pulpit abutment:-

↳ It is the modified V-abutment where the arcams of wing at right angle are made shorter.

↳ The term wingwall should be of sufficient length to prevent the retaining material from following

Imp Wing wall:-

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

Types of wing wall:-

(1) Straight wing wall

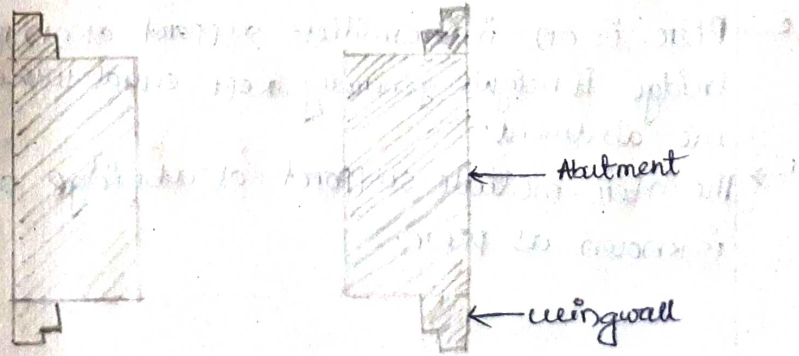
(2) Splayed wing wall

(3) Return wing wall

1. Straigth wingwall:-

↳ When the wing wall are constructed in line with the abutment are known as straight wingwall.

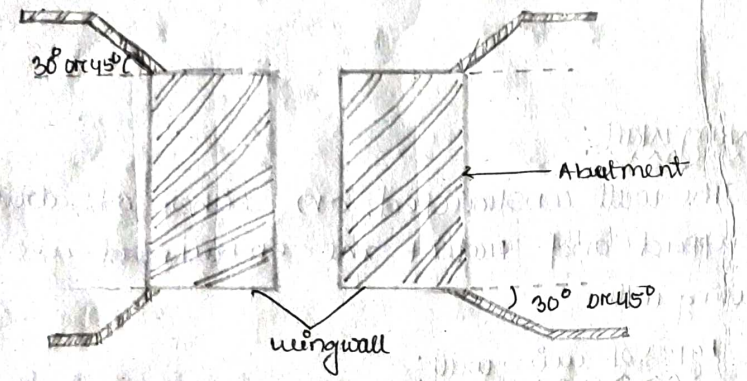
↳ This type of wing wall is suitable for small bridges which are constructed across the drain having low bank.



2. Splayed wingwall:-

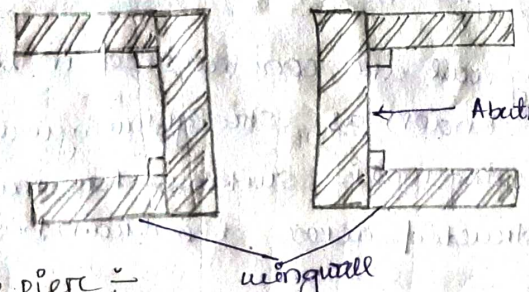
↳ When wingwalls are inclination inplan they are known as splayed wingwall.

↳ The splayed are inclination is usually 45° or 30°.



(3) Return wingwall:-

When angle of inclination become 90° the wingwall are known as return wing wall such wingwall are prefered 2 splayed wall in case of every high embankment.



Bridge pier:-

↳ Pier is an intermidiet support of an multispan bridge it height generally kept equal to the height to the abutment.

↳ The inter-mediate support of a bridge super structure is known as pier.

Types:-

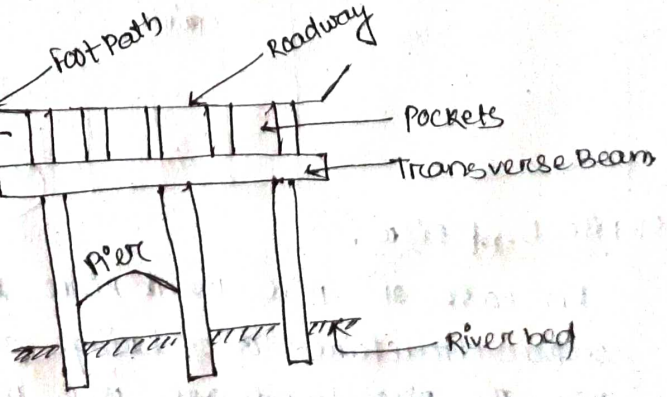
1. Column bent
2. Cylindrical pier
3. Dumb bell pier.
4. Pile bent
5. solid pier
6. Trestle pier

(1) Column Bent:-

↳ A column bent type of pier is adopted if the longitudinal beam of the supper structure are closely spaced.

↳ The transverse beams are provided to support the longitudinal beam ~~of the super structure are~~ and 2 or more columns on a solid foundation are constructed to support the transverse beam.

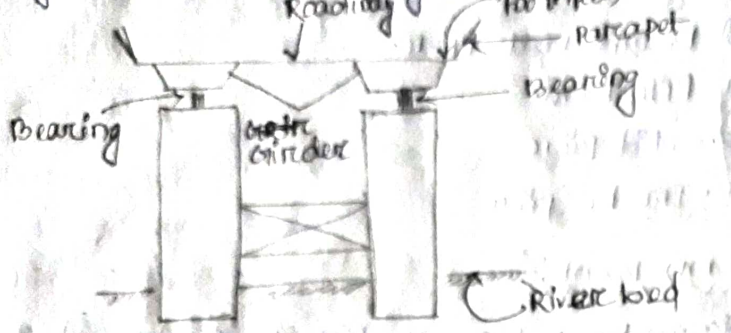
↳ The pockets from ~~below~~ beth the longitudinal beam may be to carry gas pipe, water pipe and sewage pipe.



Cylindrical pier:-

↳ A cylindrical pier consist of mild steel cylinder connected by the horizental and digonal

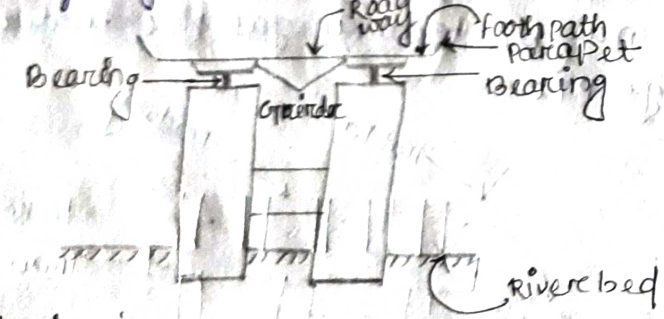
↳ These pipes are adopted when foundation are of steel cylinder can - types:



(3) Dumb Bell Pier :-

↳ A dumb bell piere has an appearance of a dumb bell it is adopted when the super structure of a bridge supported on twin girder.

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



4. Pile bend Pier :-

In case of pile bent piere the girder of supere structure of a bridge supported on RCC pile. The pile bents are use for low piers overs unstable ground.

(5) Solid pier :-

↳ In case of solid piere the pier consist of masonary or cement concrete solid section through out the entire length.

↳ Such type of construction of piere is very popular in bridge construction mainly from two reason.

(i) For any types of supere structure of the bridge.

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

Trestle Pier :-

↳ A transtle piere is a frame pier and it consist of vertical, horizontal, diagonal main bars.

↳ The trestle bend may be of steel or concrete.

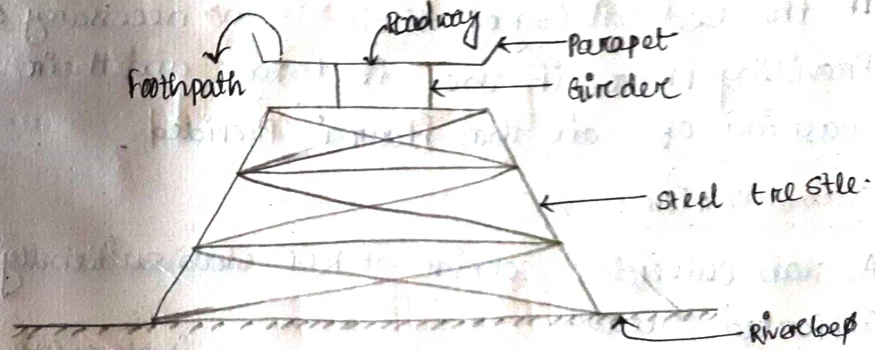
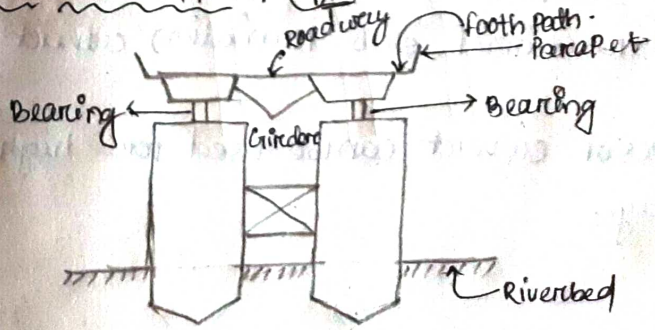


Diagram of pile bend pier :- (4) NO



Culvert:-

A culvert is a small bridged 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 culverts:-

(1) Arch culvert.
(2) Slab culvert.
(3) Pipe culvert
(4) Back culverts

(1) Arch culvert:-

↳ An arch culvert consist of abadments, wings wall, parapet and faundation.
↳ The construction materials commonly 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 flour is provided.

(2) Slab culverter:-

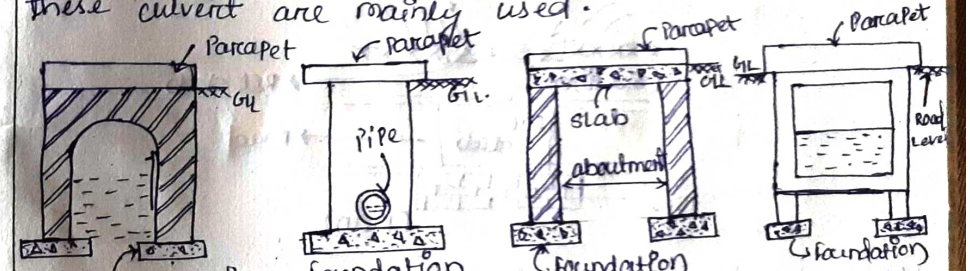
↳ A slab culverter consist of RCC slab suitabelly supported on wall.
↳ A slab culvert of simple types are suitable upto max span of 2.5 mt.
↳ The construction of slab faundation culvert is very simple.
↳ This types of culvert can be used for highway as well as railways.

(3) Pipe culvert:-

↳ They are provided when discharge of stream is small.
↳ Usually one or more of diameter not less than 600mm are placed side by side.
↳ Theire exact no. of diameter depend upon the discharge of water.
↳ Pipe may be masonary cement concrete iron or steel.

(4) Box culvert:-

↳ These culvert may be mainly consist of one or more no. of square or rectangulare opening for passing the waters from one side to another side.
↳ In soft ~~solid~~ soil when their is possibility of scouring of scouring and being capacity of soil is poore these culvert are mainly used.



Cause way:-

The cause way is defind as a small submersible bridge at or about bed level which will allowed the flood to pass over it.

Types of cause way:-

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

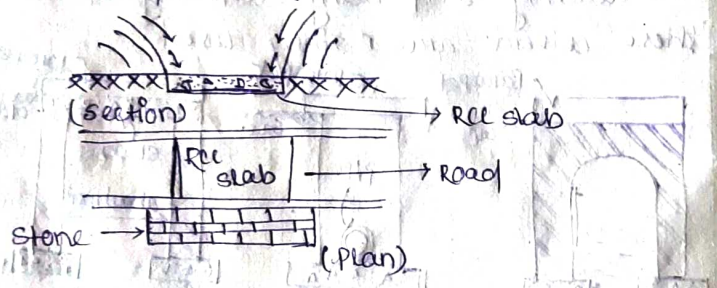
(1) Flush causeway :-

↳ In this types of causeway only pavement done in the stream bed and no vent is provided. The stream water flows continously over the paved bed through the year.

↳ some times R.C.C slabs is provided in the bed level for giving smooth surface.

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

↳ Flush causeways are provided in hilly areas when the max^{m} depth of water does not exceed 1.7 mtr in flood and the total interruption does not exceed 15 days in the hole period of one year.



(2) Low Level causeway :-

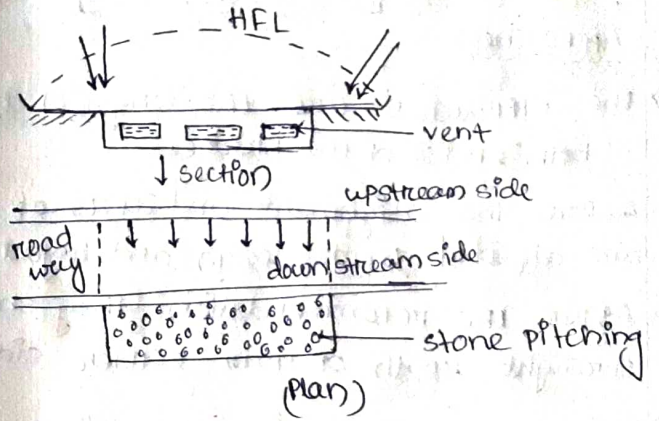
↳ In some stream the depth of water generally remains about 30cm for most of period of year. and the heavy discharge comes only in raing season for a few hours only.

↳ In such cases low level causes way are very usefull fore the traffic.

↳ small openings about 30-35cm are provided below the road way slab, so that the winters and summers discharges can pass through these vents without distrubing the traffic.

↳ Then 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 consusted 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.

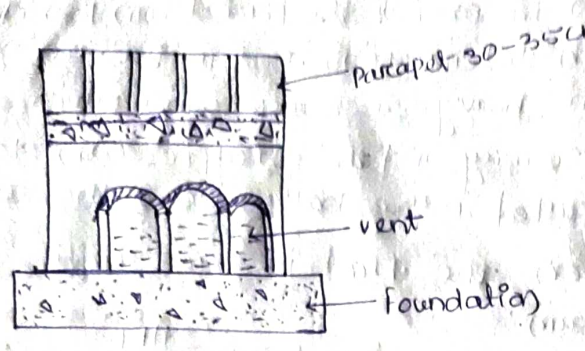
↳ This may be defind as a bridge which allowes normal flood to pass through its vent and heavy flood waters pass over it.

↳ These may be constructed on firm or rocky or loose soil bed. Thick cement concrete is 1st laid on the bed, over which vent of required section are constructed.

↳ At the top of the vent R.C.C slab is laid over which grafic 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~~ combination route at both ends of the bridge.

↳ ~~As Per~~ The alignment and levels of the approaches are affected by the design and layout of the bridge.

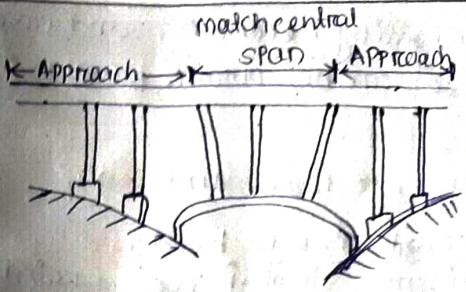
↳ As per IRC recommendation they should have a min^m straight length of 15m either side of a bridge.

↳ This length of 15m may be increased where necessary to provide min^m sight distance for the design ~~load~~ speed.

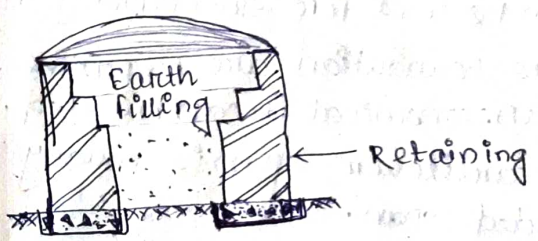
↳ This straight length of approach should have minimum surfaced width equal to the roadway on the bridge itself.

Types of Approaches:-

↳ In case of arch and ~~super~~ suspension bridge some times it is economical to covere only the central mejore 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.



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



Masonary Bridge:-

↳ masonary arch bridges are very commonly used for road bridges of moderate span.

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

↳ ~~There are~~ Three types of masonary bridges are.

1) Stone masonary bridge
2) Brick masonary arch.
3) cement concrete masonary arch.

Rain forced cement concrete bridges:-

↳ It produce maintenance free structure.

↳ No clearing or Painting after every 5 year is _

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

↳ It consist of decks, T-beam and less.

Types of reinforced cement concrete bridges :-

1) Slab bridge :- ↳ It is the simplest type of rainforced cement concrete bridge and is easiest to construct.

↳ It is ~~sub~~ suitable ~~beek~~ for submesible bridge.

↳ It is suitable for spans upto 8 meters.

(2) Grider Bridge :- ↳ It is economical for spans bet^n 10m to 20

(3) Balanced cantilever Bridges :-

↳ It consists of spans simply supported over cantilivers.

↳ It can be used for span varying from 35m to 60m.

↳ Where foundation are expensive and small span are uneconomical it can be used.

↳ The cantilever span is usually 20m-25m of the supported span.

4. Continous Bridges :-

↳ These are bridges is continue unbroken over more than one span.

↳ End spans are made about 16-20% smaller than the intermediate span. It used for large spans.