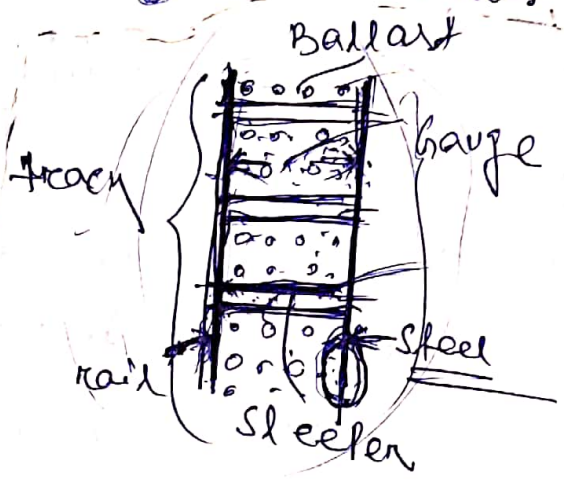
TH-03 CH-1 Railway & Bridge Engineering 5th sem 23.07.20

Railway Engg. :- It is the branch of civil engg. which deals with the construction & maintenance of the railway track for safe & efficient movement of trains on it.

Railway track :- It is the structure provided by rails fitted on sleepers, resting on ballast of wheels.



Rails :- Rails are steel griders. which provide the hard & smooth surface for movement of wheels of a locomotive & railway vehicles.

Sleeper :- Sleepers are members generally laid transverse to the rails on which the rails are supported & fixed to transfer the loads from rails to the ballast, subgrade below.

- → To support the rails firmly & evenly.
- → To maintain gauge of the track correctly.
- → To distribute the weight common on the rails over a sufficiently large areas of the ballast.

permic

Ballast :- It is the granular material packed under & around the sleepers to transfer loads from sleeper to ballast. It helps in providing elasticity to the track.

Advantages of railway

(i) Political advantages
(ii) Social "
(iii) Economical "

Political :- Railways have united the people of diff. castes, religions & traditions.

→ The control administration has become more easy, effective inadequate network of railways.

→ Railways have helped in the mass migration of the population.

→ Railways have controlled towards development a national mentality in the minds of people.

Social :- Railway has made it easier to reach places of religious importance.

→ Railways provided a convenient & safe mode of transfer for the country.

Economic :- Railways provide employment to millions of people. ~~Thus help is~~

Railway & Bridge Engg.

Classification of Indian Railways

2 Parts

- Based on routes
- Based on speed criteria

Based on routes

- Trunk route
- Main line
- Branch line

Based on speed criteria

- Group A
- Group B
- " C
- " D
- " E

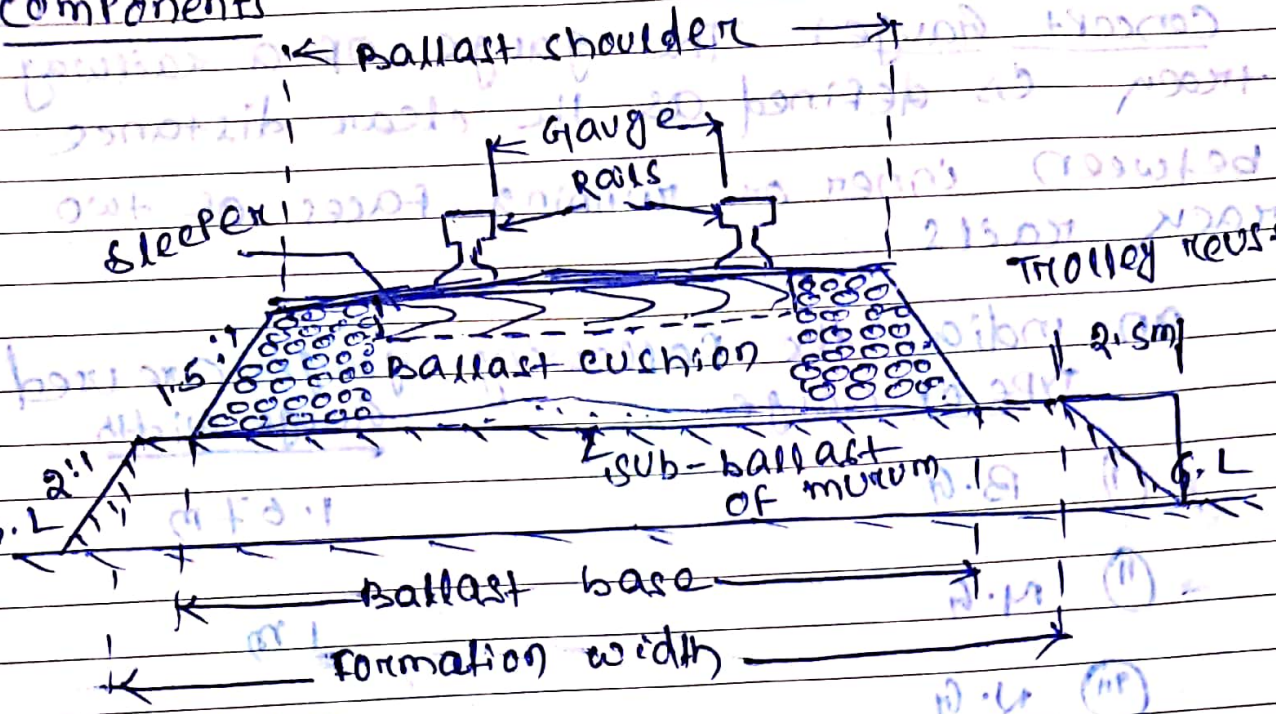
Ch-2

Permanent way → The combination of rails, fixed on sleeper, resting on ballast & subgrade is called railway track or Permanet way.

Componets of Permanet way

(I) Rails
(II) Sleeper
(III) Ballast
(IV) Bearing Plate
(V) Fish Plate
(VI) Blocks
(VII) Spikes
(VIII) Bolts
(IX) Chairs

Components



Requirements of an ideal permanent way :

→ The gauge should be correct and uniform.

→ The rails should be in proper level, in a straight track, two rails must be at the same level.

→ The alignment should be correct i.e. it should be free from kinks or irregularities.

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

→ The track structure should be strong, low in initial cost as well as maintenance cost.

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

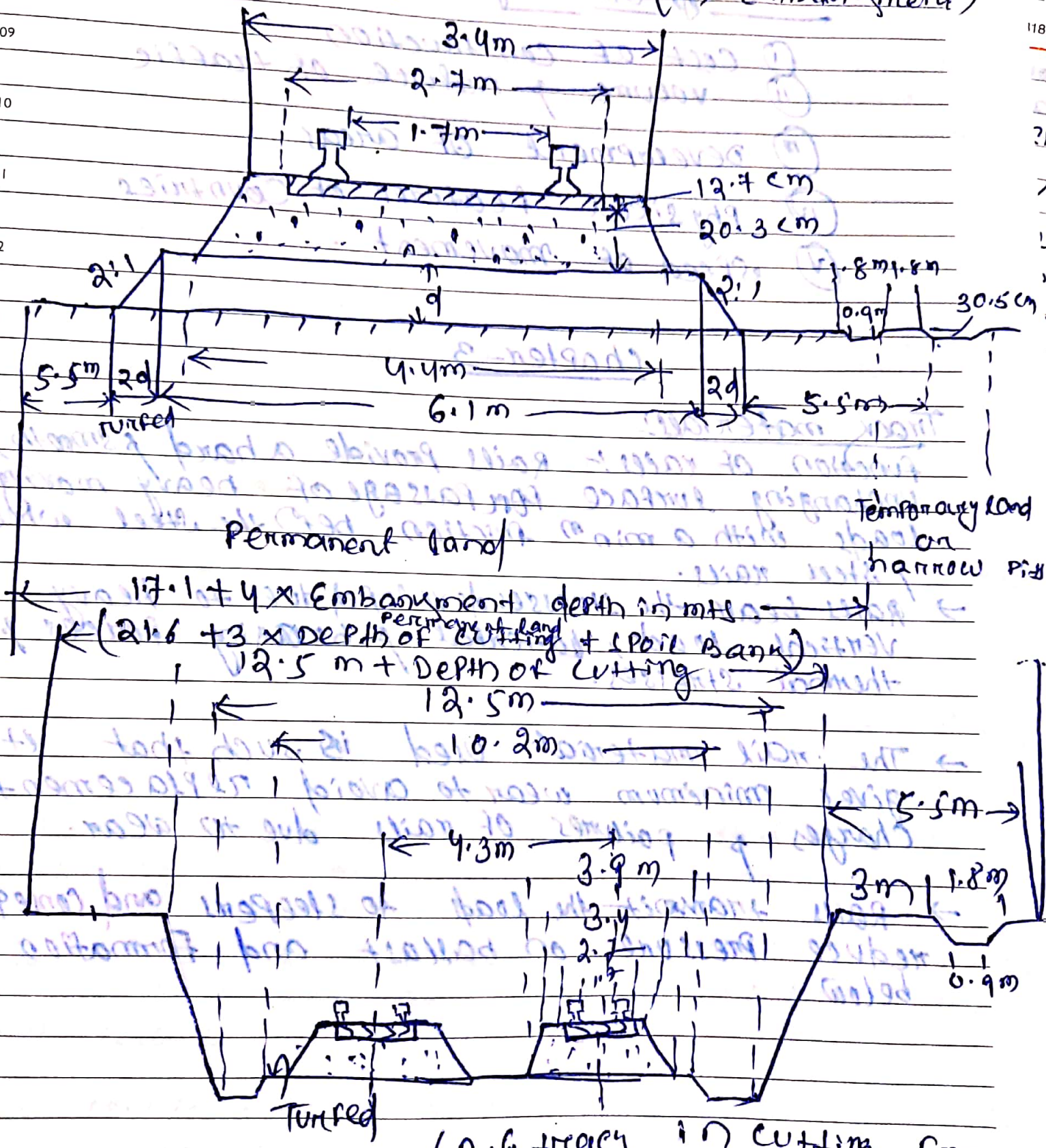
In India the following gauges are used:

Type of Gauge	Gauge width
(i) B.G	1.67 m
(ii) M.G	1 m
(iii) N.G	0.762 m
(iv) L.G	0.61 m

Railway track cross-sections:

The typical c/s of a single line and double line, in cutting and embankment, on straight and curved track.

Single (B.G track (in Embankment)



(B.G track in cutting for Double line)

Selection of Gauge

(i) Cost of construction
(ii) volume & nature of traffic
(iii) Development of areas
(iv) Physical features of Countries.
(v) speed of movement.

Chapter-3

Track materials:

function of rails:- Rails provide a hard & smooth & unchanging surface for passage of heavy moving loads with a min^m friction bet^n the steel wheels & steel rails.

→ Rails bear the stresses developed due to heavy vertical loads, lateral & braking forces & thermal stresses.

→ The rail material used is such that it gives minimum wear to avoid replacement charges & failures of rails due to wear.

→ Rails transmit the loads to sleepers and consequently reduce pressure on ballast and formation below.

Rails

The rails on the track can be considered as steel girders for the purpose of carrying axle loads. They are made of high carbon steel to withstand wear & tear.

→ F.f rails are mostly used in railway track.

Requirements of Rails

→ Rails should be made up high carbon proper composition & should be manufacture by proper process.

→ Rails should be capable of withstanding lateral forces.

→ The head must be sufficiently deep to allow for an adequate margin of vertical wear. The wearing surface should be hard.

→ web of rails should be sufficiently thick to bear the load coming on it.

→ foot should be wide enough so that rails are stable against overturning especially on curves.

The C.G of the rail section must lie approximately at mid-ht. so that max^m tensile & compressive stresses are equal.

The tensile strength of the rail piece should not be less than 72 kg/m^2.

Types of Rail section

08

(I) Double headed rails
(II) Bull headed rails
(III) Flat footed rails

09

10

Double headed:

11 The rails used were double headed (D.H) of a dumb-well sec'n.

12

→ The idea behind using of these rails was that when the head has worn out in course of time, the rail can be inverted and reused.

01

02

Bull headed rails: B.headed rails is almost similar to the double headed rails.

03

04

05 → The only diff. bet'n double headed rails is that in bull headed rails more metal is added to the head to allow greater wear and tear.

06

07

→ The lower head was get up just sufficient size to be able with stand stresses to be induced by the moving load.

17 Sunday

F.F. Rails:

→ Charles Vignoles develop a inverted 'T' sec'n known as F.F rail in 1836. F.F rail is also known as Vignole's rail.

→ F.F. rails are mostly used in railway tracks

~~Length of Rail~~ : F.F Rails

Merits (i) They have more strength & stiffness both vertically & laterally than B.H rails.

(ii) Fitting of rails with sleepers is simpler, so they can be easily laid & repaired.

(iii) No chairs or keys are required as in case of B.H Rails.

Demerits : The fittings get loosened more frequently than in case of B.H Rails.

B.H Rails : Merits : They keep better alignment & give more solid & smoother tracks.

→ They have less strength & stiffness.

→ The rails are easily disconnected from sleepers

give longer life to wooden sleepers & greater stability to the tracks.

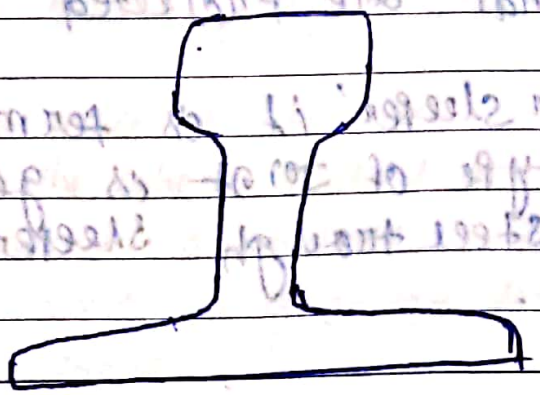
Demerits

→ They require additional cost of iron chairs.

→ They have less strength & stiffness.

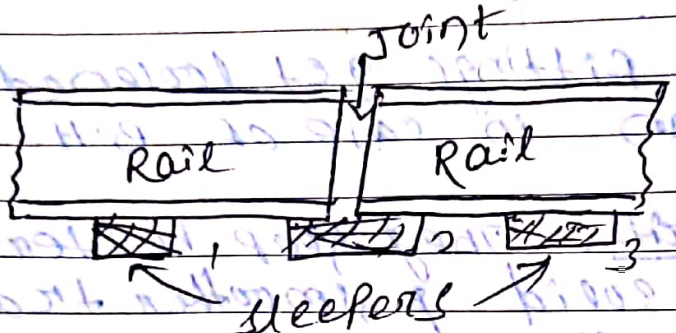
→ They require heavy maintenance cost.

F.footed

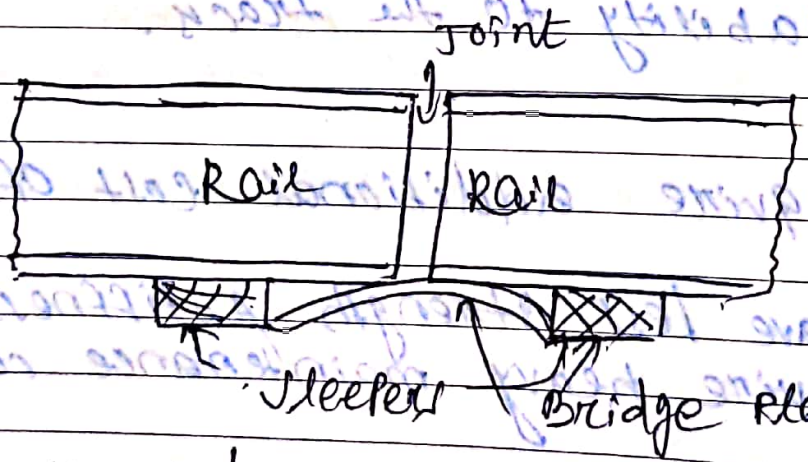


Types of Rail Joints:

① **Supported Rail Joints** :- When the rail ends rest on a single sleeper called a "Joint sleeper" it is termed as "supported joint".
→ Three sleeper support with long fish plate i.e. combined support & suspended joint is most objectionable.



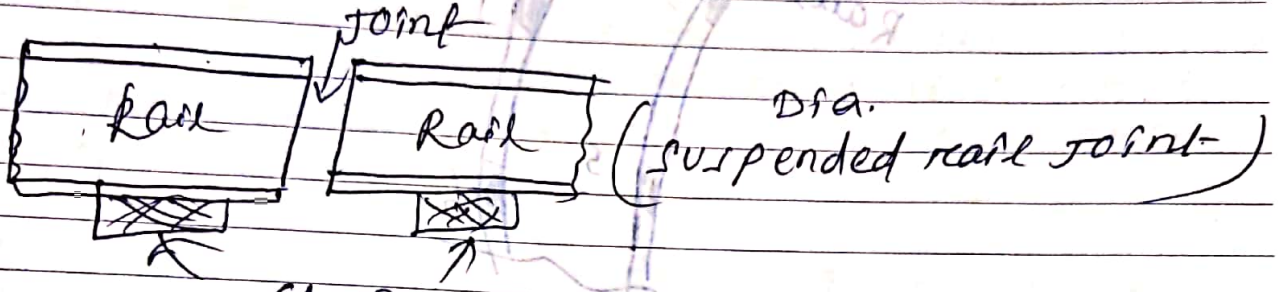
② ~~Bridge Joint~~ :- Suspended Rail Joint :



(Fig. Bridge Joint)

When rail ends are projected beyond sleepers called 'shoulder sleeper' it is termed as suspended joint. This type of joint is generally used with timber & steel through sleepers on Indian and foreign railways.

3) Bridge Joint :- When the rail ends are projected beyond sleepers as in case of suspended joint & they are connected by a flat or corrugated plate called a 'bridge plate', it is termed as a bridge joint. This type of joint is not used on Indian railways.

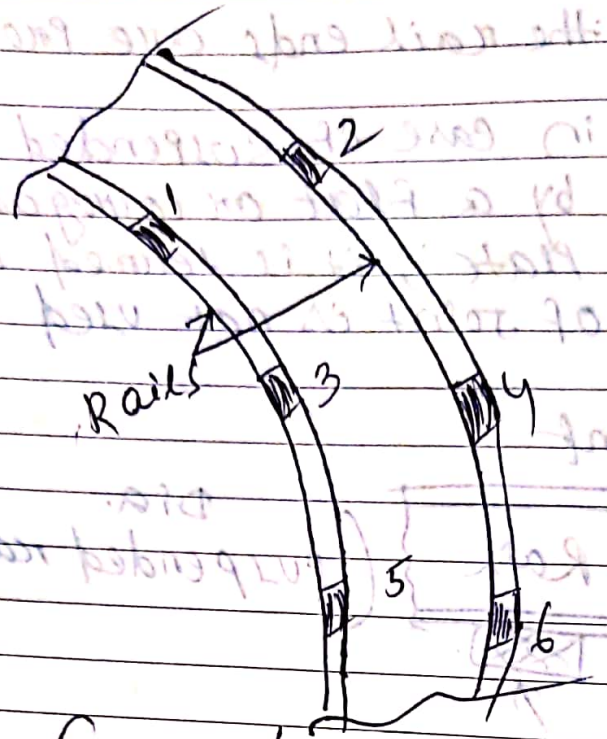


Dia. (Suspended rail joint)

4) Base Joint :- This is similar to the bridge joint, with the difference that the inner fish plates are of bar type and outer fish plates are of the special angle type. ~~(a) which the~~ Due to complicated design, this is not generally used.

5) Welded rail Joints :- These are the best joints as they fulfil nearly all the requirements of an ideal or perfect joint. ~~It will be discussed~~ in

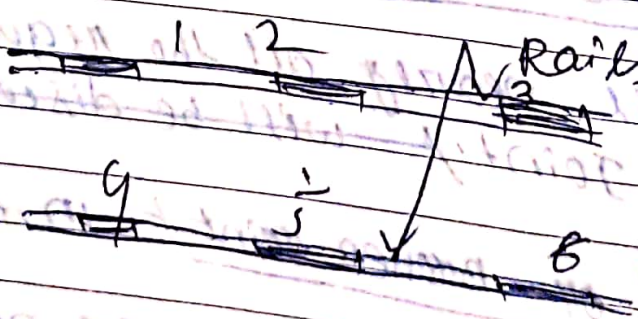
6) Staggered or Broken Joint :- In this type of joint, the joints of one rail track are not directly opposite to the joints of the other rail track. This joints are generally provided on curves., where the length of outer curved track is greater than the length of inner curved track.



(Staggered rail joint)

7) Square or Even Joint :- (In this also, the position of rail joint as the basis) on the's joints of one rail tracy are directly opposite to the joints of other rail tracy. This type is generally used on straight tracks.

8



Insulated Joint :- When insulating medium is inserted in a rail joint to stop the flow of current beyond the track circuited part, it is called insulated joint.

Compromise Joint :- Where two different rail sections are required to be joined together. it is done by means of fishplates which fit both the rails & this is joint termed as compromise joint.

Expansion Joint :- In bridges, provision for expansion & contraction is kept for girders & rails both.

Requirements of an Ideal Joint :-

(1) The two rail ends should remain true in both laterally and vertically when trains move on the track. This is necessary to avoid wheel jumping or changing its correct path of movement.

(2) The rail joint should be as strong & stiff as the rail itself & should be elastic both laterally & horizontally.

(3) The rail joint should provide enough space for free expansion & contraction to account for the effect of temp. variations.

(iv) It should not allow the rail ends to get battered in any case.

(v) The joint should fulfil the above requirements with the min^m of initial & maintenance cost.

Purpose of welding of rails :-

Welding of rails serve the following purposes :

(i) To increase the length of the rail by joining two or more rails and thus to reduce the number of joints and requirements of fish plates, which lead to economy & strength.

(ii) To repair the worn out or damaged rails & thus increase their life.

(iii) To build up worn out points & rails on the sharp curves.

(iv) To build up the burnt portion of rail head which is caused due to slippage of wheels over the rails or other defects or spots in rail steel.

Advantages of welding rails

→ It satisfies the condition of a perfect joint and hence increase the life of the rail, as also the reduction in maintenance cost of track by about 20 to 40 percent.

→ It reduces the creep due to increase in the length of rail and in turn friction as well.

→ Expansion effect due to temperature is reduced which in turn also reduces the creep.

→ welding increases the life of rails due to decrease on the wear of rails at joints.

· welding rails provides on large bridges for the span length are helpful as they result in better performance.

The cost of track construction by welding of rails decreases due to less number of rail joints.

Creep of rails

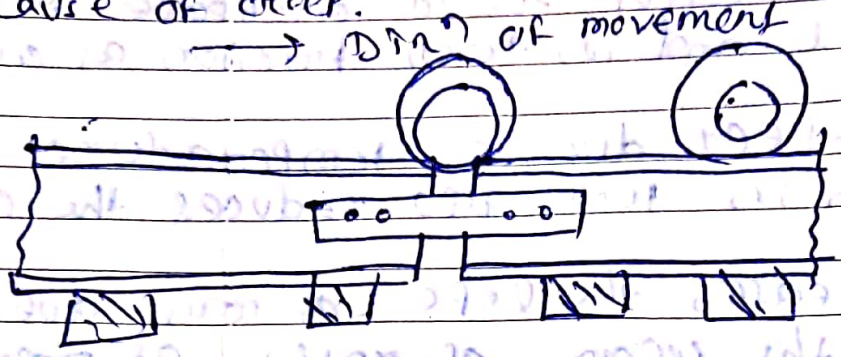
Def? :

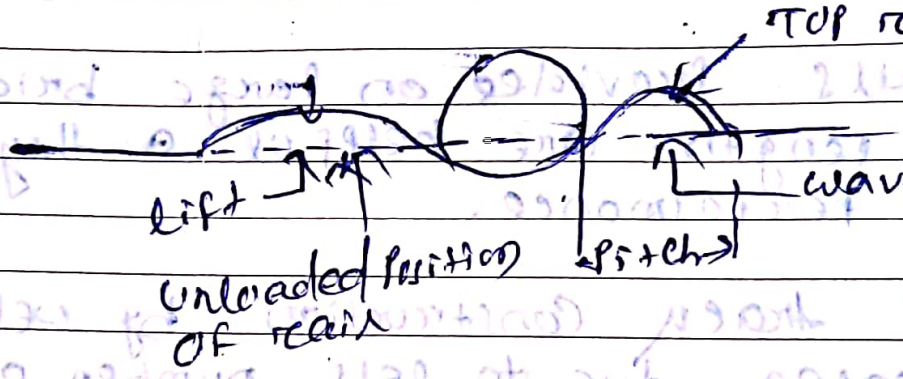
Creep is defined as the longitudinal movement rails with respect to sleepers in a track.

Cause

① Wave action or wave theory :-

Wave motion is set up by moving loads of wheels.
→ The vertical reverse curve is formed on the rails ahead of the wheels, resulting from the rail deflection under the load, is the chief cause of creep.

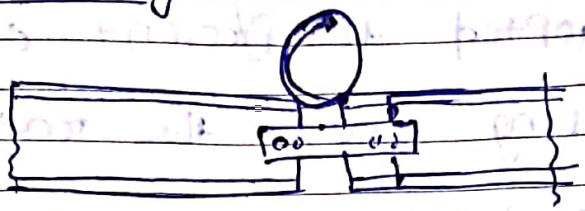




The pitch and depth of wave depend upon the following :-

(i) Tracy modulus
(ii) Stiffness of tracy
(iii) Stability of formation

Percussion theory:



The creep by this theory will increase due to the following factors:

(i) Due to weak and loose fish bolts
(ii) Due to worn out fish plates
(iii) Due to loose packing at joints.
(iv) Due to wide expansion gap.
(v) Due to heavy axle loads moving at high speeds.

(3) Dragging theory:

(4) Starting, Accelerating, slowing down or stoping of a train

(5) Expansion or contraction of rails due to temp.

(6) Unbalanced traffic

Prevention

Prevention is always better than cure. If creep is not prevented in time, it will result

In derailment, following are the common methods adopted to prevent creep.

(1) Pulling back the rails

(2) Provision of Anchors & Anticreepers

Sleepers

Sleepers are members generally laid transverse to the rails on which the rails are supported and fixed, to transfer the loads from rails to the ballast, sub grade below.

Function

→ To hold the rails to correct gauge and alignment.

→ To hold the rails in proper level i.e. level in turnouts, cross overs etc. so as to provide a firm even support to rails.

→ To transfer and distribute the load through rail over a sufficient larger area of ballast.

→ To act an elastic medium in bet'n the ballast and rails to absorb the blows & vibrations of moving loads.

→ To support the rails at a proper level in straight tracks and at proper superelevation on curves.

Requirement an Ideal Sleeper:-

08 ⇒ The sleepers to be used should be economical i.e;
They should have minimum possible in deal
09 maintenance cost.

⇒ The weight of sleepers should not be too
11 heavy i.e; they should have moderates weight,
for ease of handle easily.
12

→ The design of sleepers should ~~not~~ be such that the
01 gauge, alignment of track, levels of the rails
can be easily adjusted and maintained.
02

→ The sleepers should be capable of resisting shocks
03 and vibrations due to passage of heavy loads at
high speed trains.
04

→ The design of the sleepers should be such that
05 they are not damaged during packing processes.
→ The sleeper design, spacing should be such as to facilitate easy
06 removal & replacement of ballast.

Classification of sleepers

07

(1) (a) wooden sleepers
(2) Metal sleepers
    (a) Cast iron sleepers
    (b) Steel sleepers
(3) Concrete sleepers

SATURDAY
WEEK 05 / DAY 030-336 2016

Advantages of wooden sleepers :

→ Timber is easily available in all parts of india.
→ Fitting for wooden sleepers are few and simple in design.
→ Wooden sleepers are easy to lay, relay, pack, lift and maintain.
→ These wooden sleepers are suitable for all types of ballast.

Disadvantages :

→ The sleepers are subjected to wear, decay attacy by white ants, warping, cracking etc.
→ It is difficult to maintain the gauge in case of wooden sleepers.
→ Track is easily disturbed i.e. alignment maintenance is difficult.
→ Wooden sleepers have got minimum service life (12 to 15 yrs) as compared to other types of sleepers.

Metal sleepers

Metal sleepers are either of steel or cast iron. Cast iron is in greater use than steel for sleepers becz it is less prone to corrosion.

31 Sunday

Advantages

08 → Metal sleepers are uniform in strength & durability.

09 → in metal sleepers, the performance of fittings is better and hence lesser creep occurs.

10 → Metal sleepers are economical, as life is ~~strength~~ longer & maintenance is easier.

11 → Gauge can be easily adjusted & maintained in case of metal sleepers.

12 → for metal sleepers, frequent renewal is not required

01 Disadvantages

02 → More ballast is required than other type of sleepers.

03 → fittings required are greater in number, &

04 difficult to maintain & inspection.

05 → Metal sleepers are unsuitable for bridges, level crossings & in case of points & crossings.

06 → These sleepers are only suitable for stone ballast

07 & for rails for which they are manufactured.

Concrete sleepers:

Adv:

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

→ They have max^m life when compared to other sleepers, the life under normal conditions is 40 to 60 yrs (as compared to 15-20 yrs for wooden

07 TUESDAY 10 | 29
WEEK 06 / DAY 033-333 2016

→ This is not affected by moisture, chemical action of ballast & sub-soil salt.

→ The sleepers have higher elastic modulus & hence can withstand the stresses induced by fast & heavy traffic.

Disadvantages

→ The weight of concrete sleepers is as high as 2.5 to 3 times of wooden sleeper.

→ They damage the bottom edge during the packing.

→ The damages to the concrete sleepers is very high in case of derailment.

13 14 | 21 22 23 24 25 26 27 28 29 30 31

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2016 | WEEK 06 / DAY 034-332

Ballast

It is the granular material usually broken stone or brick or kankar, gravel or sand placed & packed below & around the sleepers to transmit load from sleepers, to formation & at the same time allowing drainage of the tracks.

→ It provides a suitable foundation for the sleepers & also hold the sleepers on their correct level & position, preventing their displacement by lateral

Functions of Ballast

→ It transfers the load from the sleeper to the subgrade & then distributes it uniformly over a larger area of the formation.

→ It holds the sleepers in position & prevents the lateral & longitudinal movement, due to dynamic loads & vibrations of moving trains.

→ It provides easy means of maintaining the correct levels of the two rails of a track & for correcting track alignment.

→ It provides good drained foundation immediately below the sleepers & helps to protect the top surface of the formation.

Requirements:

→ It should be able to withstand hard packing without disintegrating.

→ It should not make the tracks dusty or muddy due to powder under dynamic wheel loads but should be capable of being cleaned to provide good drainage.

→ It should allow for easy drainage with minimum soakage & the voids should be large enough to prevent capillary action.

→ It should not produce any chemical action with rail & metal sleepers.

→ The size of stone ballast should be 5cm for wooden sleepers, 4cm for metal sleepers & 2.5 cm for turnouts & crossovers.

→ The ballast should be available in nearby quarries so that it reduces the cost of supply.

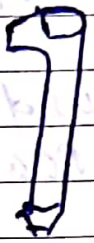
Materials of Ballast

The diff. materials used as ballast in India are broken stone, gravel, sand, soft aggregates like moorum, kankar & broken bricks & sometimes selected earth.

Connection of Rails to rail fishplate & Purpose & types

Track fittings & rail fastenings are used to keep the rails on the proper position & to set the points & crossing properly.

1. fishplates
2. spikes – (i) Dog spikes
   (ii) screw "
   (iii) Round "
   (iv) Elastic "
3. Bolts (i) Dog (ii) fish bolt.
4. Chairs (i) Cast steel chairs
   (ii) Mild steel "
5. Blocks (i) Heel Blocks
   (ii) Crossing "
6. Bearing plates.



Requirements of fishplate :-

They must support the underside of the rail & top of the foot.

They should allow a free movement of rails for expansion & contraction. For this purpose they should not touch the web of the rail.

They should hold the ends of the rail both laterally in line & vertically in level.

→ To bear the stresses due to lateral & vertical
08 B.Ms without getting distorted.

09 **Spikes:** To holding the rails to the wooden sleepers.

10 **Requirements:**

11 → The spike should be strong enough to hold the rail in position.

12

→ It should be as deep as possible, for better
01 holding power.

02 → It should be easy to fixing & removal from the sleepers.

03

→ It should be cheap in cost.

04

→ It should be capable of maintaining the gauge.

05

Fish bolts:

06

Fish bolts are made of medium or high
07 carbon steel. For 44.70 kg rail, a bolt of 2.5 cm dia & 12.7 cm length is used.

→ Generally the length of bolt depends on the
07 Sunday type of fish plate used.

Length of Rails :-

The rails of larger length are Preferred to smaller length of rails, becz they give more strength & economy for a railway track → The weakest point of a track is the joint between two rails. Lesser the number of joints, lesser would be number of fish plates & this would lead to lesser maintenance cost, smoother running of trains & more comfort to the Passengers. Moreover the more number of joints would increase wear & tear of the vehicle components, including wheels.

The long length of the rails is desired, however the length is governed by the following factors :-

(1) The length of the rails is so chosen that the manufacturing cost is most reasonable

(2) It depends upon the transportation facilities so only those lengths of rails are Possible which can be transported by longest wagons available on the railways.

(3) More the length of the rail, more will be the gap required for expansion of rail due to temp. but however the expansion is not Proportional to gap IMPORTANT because fastenings check the movement of rails, So expansion gap is not limiting factor for length of rails through it effects to some extent

On Indian Railways the standard lengths are the following:

length = 12.80 m (42 ft) for B.G (say 13 m)

length = 11.89 m (39 ft) for M.G (say 12 m)

Rail Joints:

Rail joints are necessary to hold together the adjoining ends of the rails in the correct position, both in the horizontal & vertical planes. Rail joints form the weakest part of the track. It is observed that strength of a rail joint is only 50% of the strength of a rail.

Requirement of an Ideal Joint:

An ideal or perfect rail joint is one which provides the same strength & stiffness as the other rail sect of the track. The following requirements should be met by an ideal joint:

1. The two rail ends should remain true in line both laterally & vertically when train move on the track. This is necessary to avoid wheel jumping or changing its correct path of movements.

IMPORTANT

2. The rail joint should be as strong & stiff as the rail itself & should be elastic both laterally & horizontally.

(iii) The rail joint should provide enough space for free expansion & contraction to account for the effect of temp. variations.

(iv) A good joint should be easily disconnectable so that it can be easily taken out without disturbing the whole track for the purposes of changing rail or a fish plate & lubricating the contact faces.

(v) The joint should fulfil the above requirements with the min^m of initial & maintenance cost

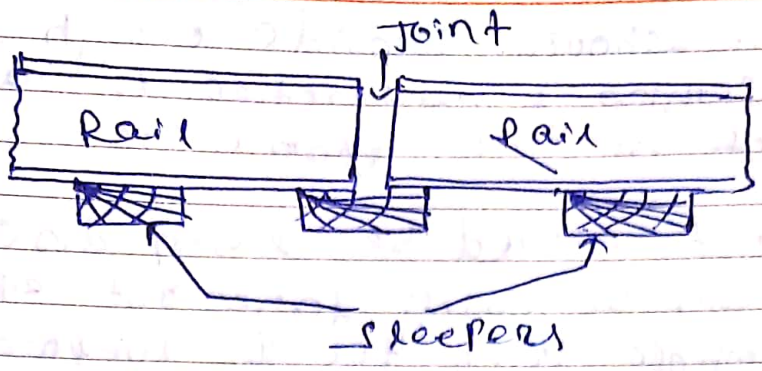
Types of Rail Joints:

The following types of joints are commonly used on indian & foreign railways.

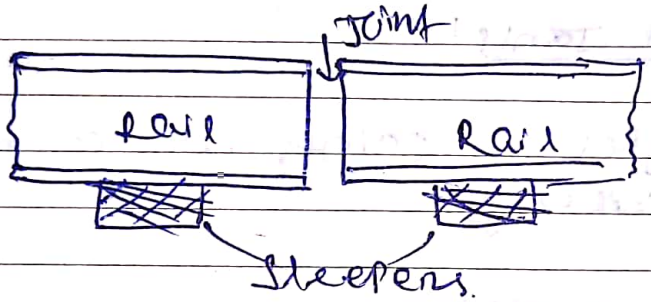
(1) Supported Rail Joints:

When the rail ends rest on a single sleeper called a "joint sleeper" it is termed as supported joint.

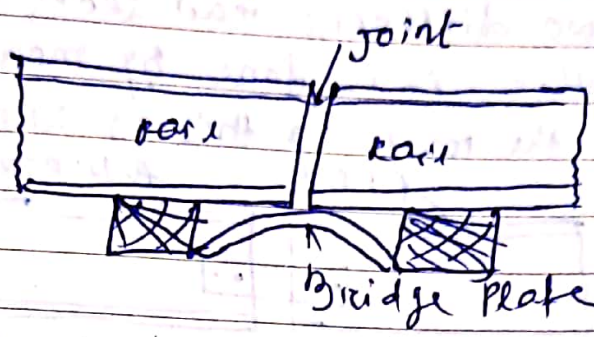
⇒ Three sleeper support with long fish plate i.e; combined supported & suspended joint is most objectionable Bcz in this case when the packing under the outer sleeper gets loose, undue load comes on central sleeper & in turn the loose central sleeper converts the joint into a weakest suspended joint



(2) Suspended Rail Joint :- When rail ends are projected beyond sleepers called shoulder sleeper" c't is termed Suspended Joint. This type of joint is generally used with timber & steel trough sleepers on Indian & foreign railways.



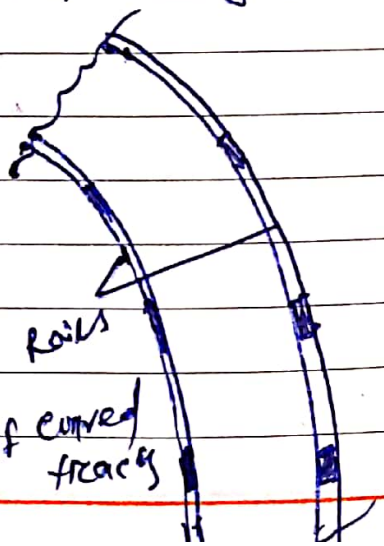
Bridge Joint: - When the rail ends are projected beyond sleepers as in case of suspended joint & they are connected by a flat or corrugated plate called a Bridge plate. It is termed as a bridge joint. This type of joint is not used on Indian Railways.

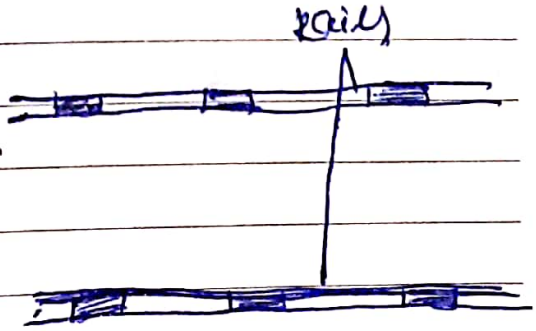


- **Base Joint:** This is similar to the bridge joint, with the difference that the inner fish plates are of bar type & outer fish plates are of the special angle type. Due to complicated design, this is not generally used.

Welded rail joints: These are the best joints as they fulfil nearly all the requirements of an ideal or perfect joint.

Staggered or Broken joint: In this type of joint, the joints of one rail track are not directly opposite to the joints of the other rail track. These joints are generally provided on curves, where the length of outer curved track is greater than the length of inner curve track.





IMPORTANT

Square or even joint: In this type of rail joints of one rail track are directly opposite to the joints of other rail track. This type is generally used on straight tracks.

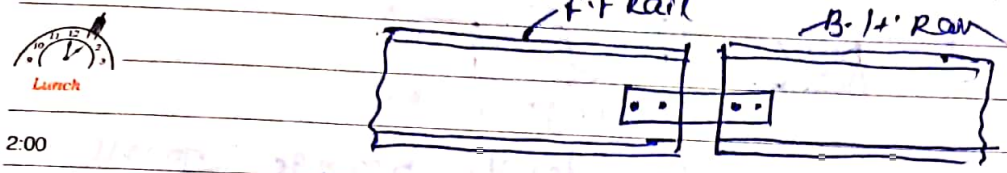
9:00

10:00

Compromise joint:

11:00 Where two different rail secy are required to be joined together, it is done by means of fish plates which

12:00 fit both the rails & this is joint termed as compromise



Lunch

2:00

Insulated:

3:00 When insulating medium is inserted in a rail joint to stop the flow of current beyond the track circuited

4:00 part, it is called insulated joint.

5:00 Expansion joint: In bridges, provision for expansion & contraction is kept for girders & rails both. This gap

6:00 is 2.2 cm in case of mitred joint & 7.2 cm for Halved joint.

7:00

The wooden sleepers are best for joints. They produce less stresses in rails & fish plates, & their performance.

Ch-4

Superelevations:- (Chapter - 04)

* To counter act the effect of the centrifugal force the level of the outer rail raised above the inner rail by a certain amount to introduce the centripetal force. The's raised elevation of outer-rail above the inner rail of a horizontal curves is known as superelevation.
* It is also known as cant.
* It is denoted by 'e'

Objects:-

* To introduce the centrepetal force to counter acting the effect of centrifugal force this will result in the faster, movement of trains on curves, this will also prevent derailment Reduce the side wear and creep of rails.
* To provide to smooth working of the track resulting in shape movement of the goods of comfortable wrie of the passanger.
* This Reduces the were of rails equipment and result in saving maintenance cost.

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

Gauge for B.G - 1.67m
M.G - 1m
N.G - 0.762m

$$e = \frac{1.676 \times V^2}{127R} \text{ (Board Gauge)}$$

$$e = \frac{V^2}{127R} \text{ (Meter Gauge)}$$

$$e = \frac{0.762 V^2}{127R} \text{ (Narrow Gauge)}$$

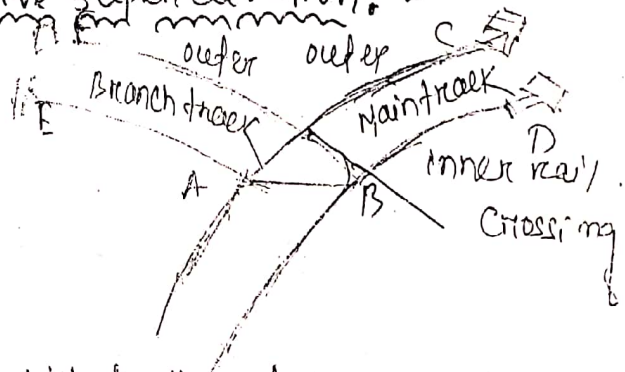
cant deficiency:-

* Equilibrium cant / superelevation is provided on the basises of the equilibrium speed (Average speed) of different trains. but this equilibrium cant / superelevation. fall shortest of that required for the high speed of train.

* This shortest of cant is called cant deficiency

Gauge	cant deficiency for speed upto 100kmph	speed higher than 100 Kmph
B.G	7.6C.m	10C.m
M.G	5.1C.m	not specified
N.G	3.8C.m	not specified

Negative superelevation:-



* At which is the outer rail of the main line must be higher than the inner rail 'BD' or in other words the point 'A' should be higher than the 'B'

* for the Branch line BF should be higher than then AE for the point B should be higher than

D: 11.07.014

* These two contradictory conditions exist at the same time within one layout. So instead of BF on Branch line being higher, it is kept lower than inner rail AE.

* In such cases Branch line curves as -ve superelevations and their Fov speed on both tracks most be restricted of particularly on branch line.

* The method of working out the speeds on branch line and -ve superelevations on branch will be clear from the following steps

$$e = \frac{GV^2}{gR} = \frac{G(m) \times (0.278V)^2 \times m^2/sec^2}{9.81\ m/sec^2 \times m}$$

$$= \left[\frac{GV^2}{127R}\right] m \text{ (or) } cm$$

$$= \frac{100G \times 100V^2}{127 \times 100R}$$

$$= \frac{GV^2}{\frac{127}{100} \times 100R}$$

$$= \left[\frac{GV^2}{1.27R}\right] inc.m$$

Step-1

The equilibrium superelevations or cant on branch line / main line is calculated by formula. After Assuming a speed on a branch line / main line.

Step-3

To differential obtained (equilibrium cant - Pe
will give the -ve superelevation missible cant defic
branch line. to be used on

Step-4

This -ve superelevations the's also equal to th
maximum superelevations permited on the ma
for track.

Step-5

This restricted speed for track is obtained b
adding permissible deficiency (in maximum
cant for on the main track and Applying
the formula.

* Problem:-01.

If a 8 degree curve track diverges from a main curve of 5 degree in a opposite direction on the layout of a Board gauge yard. calculate the superelevation and speed on the branch line. If the maximum speed permited on the main line is 115 kmph.

Ans:

main curve = 5°

branch curve = 8°

Step-1

equilibrium cant required for 45kmph speed by equations.

main curve.

V = 45 Kmph

$$e = \frac{G v^2}{1.27 R} \text{ cm (Board gauge} = 1.676)$$

$$= \frac{1.676 \times (45)^2}{1.27 \times \frac{1720}{5}}$$

$$= 7.76 \text{ cm}$$

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

D° degree of curve

Step-2

For B.G. gauge the cant deficiency for main line 7.6 c.m

Step-3

So the cant the main track
= 7.76 - 7.6 = 0.16 c.m

Step-4

Their fore the cant to be provided for branch track = -0.16 c.m
i.e -ve super elevations.

Step-5

With cant deficiency of 7.6 c.m which is permissible, the speed of the train will be for a cant of.

= -0.16 + 7.6 = 7.44 c.m

$$e = \frac{GV^2}{1.27R} \qquad R = \frac{1720}{8}$$

$$7.44 = \frac{1.676 \times V^2}{1.27 \times \frac{1720}{8}}$$

$$V^2 = \frac{7.44 \times 1.27 \times 1720}{1.676 \times 8}$$

$$V = 34.81$$

$$= 35 \text{ Kmph}$$

* Problem: 09

A 5° curve diverges from a 3° main curve in the layout of a board gauge yard. If the speed on the branch line is restricted 35 Kmph. determine the restricted speed on the main line.

Ans:

Main curve = 3°

Branch line 35 Kmph

Branch curve = 5

Step-1

equilibrium cant required for 35 Kmph speed by equations.

Branch curve.

$V = 35$ Kmph

$e = \frac{GV^2}{1.27R}$ c.m (Board Gauge = 1.676)

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

$= 4.69$ c.m

Step-2

For Board gauge the cant deficiency for branch line = 7.6 c.m

Step-3

So the cant the main track

$= 4.69 - 7.6 = -2.91$

Step-4

There for the cant to be provided for main track = 2.90

i.e +ve superelevation

Step-5

With cant deficiency of 7.6 c.m which is permissible, the speed of the train will be for cant of $= 2.91 + 7.6 = 10.51$ c.m

D: 14.07.014

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

$$10.59 = \frac{1.676 \times V^2}{1.27 \times \frac{1720}{3}}$$

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

$$V^2 = \sqrt{\frac{10.59 \times 1.27 \times 1720}{1.676 \times 3}}$$

$$= 67.6$$

$$V = 68 \text{ kmph}$$

Problem-03 (Ans)

What would be the equilibrium cant on a board gauge track of 5° curve for a speed 60 kmph.?

Ans:

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

$$= \frac{1.676 \times (60)^2}{1.27 \times \frac{1720}{5}}$$

$$= 13.81 \text{ c.m}$$

Problem :- 04

Degree of curve = 1°
superelevation (e) = 80mm, calculate the shape on the curve and speed calculated from the considerations of the superelevations.

Ans:

Degree of curve = 1°

superelevation = 80 mm = 8 c.m

maximum cant deficiency for board gauge track = 10 c.m.

Theoretical superelevation = 8 + 10 = 18 c.m

equilibrium speed for this superelevations

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

$$\therefore 18 = \frac{1.676 \times v^2}{1.27 \times \frac{1720}{1}}$$

$$v^2 = \frac{1.27 \times 18 \times 1720}{1.676}$$

$$v = \sqrt{\frac{1.27 \times 18 \times 1720}{1.676}}$$

$$v = 153.16 \text{ Km/hr.}$$

Problem: 05

If a 8° curve track diverges from a main curve of 5° in a opposite direction on the layout of board gauge yard. calculate the superelevation and speed on the branch line. If maximum speed permited on the main line 50 Kmph.

Ans:

main curve = 5°
branch curve = 8°
main line of speed = 50 Km/hr.
branch line of speed = ?

Step-1.

main line

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

$$= \frac{1.676 \times (50)^2}{1.27 \times \frac{1720}{5}}$$

$$= 9.59 \text{ c.m}$$

Step-2

For Board gauge the cant deficiency for a main line = 7.6 c.m

Step-3

So the cant for main line

$$= 9.59 - 7.6 = 1.99 \text{ c.m}$$

So the cant of superelevation is = 1.99 c.m

Step-4

Therefore the cant to be provided for broad gauge line

$= -1.99$ cm

Step-5

With cant deficeency of 7.6cm which is permissible, the speed of the train will be for a cant of:

$= -1.99 + 7.6 = 5.61$ cm

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

$$5.61 = \frac{1.676 \times V^2}{1.27 \times \frac{1720}{8}}$$

$$V = \sqrt{\frac{5.61 \times 1.27 \times 1720}{1.67 \times 8}}$$

$$V = \frac{30.28 \text{ km/hr.}}{11}$$ (Ans)

ch-4

Gradients for drainage

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

various gradients used on railway tracks can be classified under the following heads:

1. ruling gradient
2. Momentum gradient
3. pusher or Helper gradient
4. Gradients at station yards.

Chapter: 05

Points and Crossing: -

* Points and crossings, turnouts, cross-overs and such related items are arrangements by which different routes either parallel or diverging are connecting and afford the means for trains to move from one route to another.

* These connections are not only useful for trains to move from one route to another route but also helps from washing and shunting that are working in station yards.

Necessity of points and crossings: -

In case of roads, the facilities for turnings of vehicles from one path to another, don't require any special arrangement as the wheels have no flanges.

The points and crossing is important in following ways.

1. Points and crossing is important. Flexibility of movement by connecting one line to another, according to requirements.

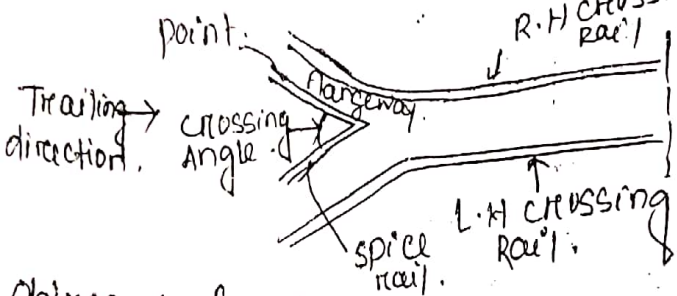
2. They also help for imposing restrictions over turnouts which necessarily reduced the movements.

3. From safety aspects, it is also important as points and crossing are weak links on points on the tracks and vehicles are susceptible to detailment at these places.

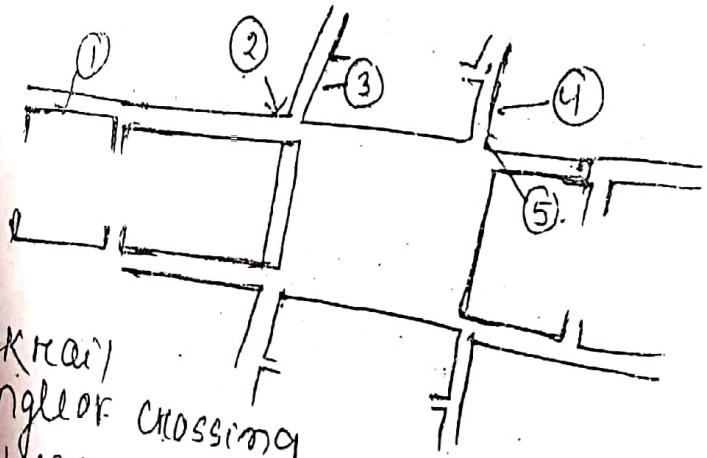
Types of crossing:-
1. Acute crossing
2. Obtuse " (
3. Square "

Crossings:-
A crossings is a special form or construction for providing a flange way clearance between two rails to be crossed. Different pieces of rail shaped and connected together are used for preparing a crossing.

Acute Angle crossing:-
Acute Angle is formed when a right hand rail of one track crosses left hand rail of another track at an acute angle.

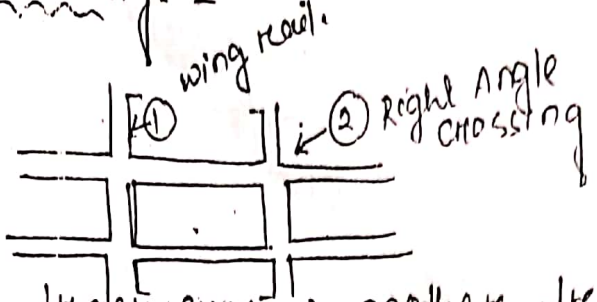


Obtuse Angle crossing:-
This crossing is fixed when a track crosses another (or the same or different gauge) at an obtuse angle.



1. Cheek rail
2. Angle or crossing
3 and 4 wing wall
5. Acute crossing.

Square crossing:-



* when one track crosses another track at the same or different gauge at right angle.
* This type of crossing on the main line should be avoided as it causes heavy wear due to impact or moving load.

Important terms used in points and crossing:-

1. Facing direction:-

If someone stands at the toe of switch (exchange) and looks towards the crossing, then the direction is called Facing direction.

2. Trailing direction:-

If someone stands at the crossing and looks towards the switches, then the direction is known as Trailing direction.

3. Facing points of turnouts:-

Facing points of turnouts are those where the train passes over the switches first then passes over the crossings.

4. Trailing points of turnouts:-

Trailing points of turnouts are those of the opposite side of the facing points in which the train passes over the crossing first and then over the switches.

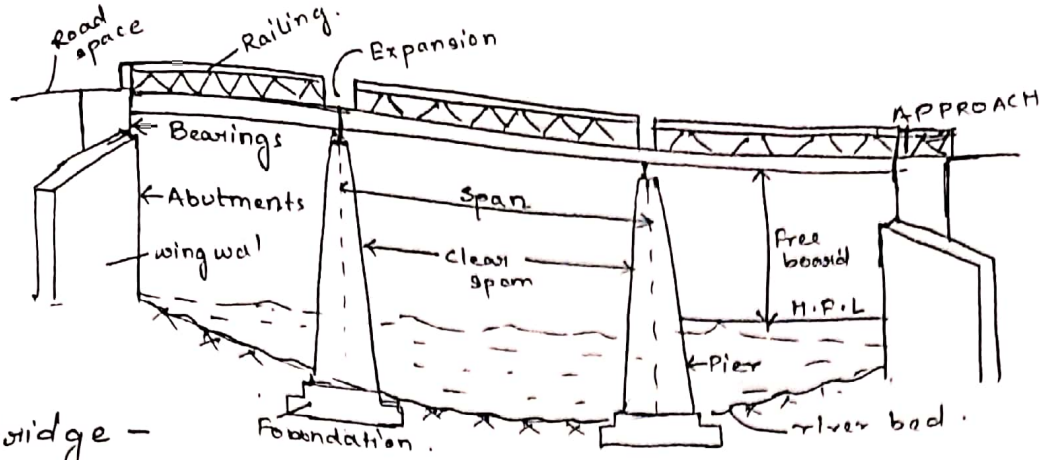
Right hand turnouts:-
If a train from main track diverted to the right of the main route in the facing direction, then this diversion is known as right hand turnouts.

6. Left hand turnout:-
If a train from the main track is diverted to the left of the main track is diverted to the left of the main route in the facing direction then the direction known as left hand turnout.

7. Right hand and left hand switches:-
It is deemed as left hand or right hand switches depending upon the right or left when seen from the facing directions, i.e stand at the points and look towards the crossing.

Plate laying:-
* The operation or laying web and connection rail and sleeper is known as plate laying.
* The point of commencement of new track to be laid on the existing rail head.
* In new track sleepers are laid directly over the formation. The track is then lifted and ballast is packed towards the sleepers.

CH-7
BRIDGE



Bridge –

It is a structure that afford passage over low ground or other structure.

The communication route over the bridge may be a roadway, footpath, cycle track & railway track.

Foundation –

These are the structure which distribute the dead load of the superstructure, piers, abutements, etc along with live loads which comming on, bridge over a large area of subsoil.

Abutments –

The end supports of the superstructure of a bridge is known as abutment.

Wing Wall –

The walls constructed on both sides of the abutment to retain the embankment of approaches and also to protect them from the wave action of water are called wing wall.

Piers –

It is the intermediate support of a bridge.

Approaches –

These are the construction works which carry the road or railway track upto the bridge.

Cut water —

This is the offstream nose of a bridge pier shaped for easy and smooth flow of water through it.

Span :—

It is the centre to centre distance between two pier or support.

Clear span —

It is the outer to outer distance between two pier.

H. F. L —

It is the level of the highest flood ever recorded of a stream or river.

Free Board —

It is the difference between the high flood level and the level of crown of the road at its lowest point.

Classification of Bridge

According to the material of construction :—

I. Timber bridge II. Masonary bridge III. Steel bridge.
IV. R.C.C bridge V. Floating bridge VI. Permanent small bridge
VII. Temporary Bridge

Selection of Bridge Site:

An ideal site for a bridge across a river should more following characteristic :-

i. At bridge site the reach of the stream should be straight.
ii. The site should be geologically sound (i.e) it should be away from fault zone, non-erodible foundation for abutment and piers (gradually destroyed).
iii. At the site, the stream should be narrow with well defined and firm banks.
iv. At site the river flow should be without whirly and cross currents.

Requirement of Ideal Bridge:-

An ideal bridge must be of following requirements:-

a) It should be economical.
b) It should serve the intended functions with almost safety & convenience.
c) It should give a esthelic elegant look.

Deck, Through and Semi-through Bridge:-

The flooring of bridge which carries the traffic can be supported at the top, bottom or at some intermidate level of the superstucture or main girders of the bridges, when it is supported at the top it is called 'deck-bridge' and when it is supported at the bottom, it is called 'Through-Bridge'. But if it is supported at some interimidiate level, it is known as 'semi-through bridge'.

[Through-Bridge]

CH-8

Site Investigation, Hydrology and Planning:-

→ Suitable, unyielding and non-erodable material for foundation should be available at a short depth for abutments and piers of a bridge. The bearing strata should be free from the tendency to slip or slide or shrink render loads and away from fault zone. In other words it should be geological suitable.

→ The stream of the bridge site should be well defined and as narrow as possible.

→ There should be a stretch reach of stream at bridge site.

→ The site should have firm, permanent, straight and high banks.

→ The flow of water in the stream at the bridge site should be is steady regime condition. It should be free from whirls and cross currents.

→ There should be no confluence of flange tributaries in the vicinity of bridge site.

→ It should be reasible to have straight approach roads and square alignment i.e right angled crossing.

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

→ There should be minimum obstruction of natural waterway such as to have minimum afflux.

→ In order to achieve economy, there should be easy availability of labour, construction material and transport facility in the vicinity of bridge site.

→ In order to have minimum foundation cost, the bridge site should be such that no excessive work is to be carried inside the water

→ At the bridge site should be possible to provide secure and economical approaches.

→ In the case of curved alignments the bridge should not be on the curve but preferably on the tangent since otherwise there is a greater likelyhood of accident as well as an added centrifugal force which increases the load effect on the structure and will require modification of design.

→ There should be reasonable proximity to a direct alignment of the roads to be served i.e avoidance of long detours.

→ The bridge site should be such that adequate vertical height and waterway is available underneath the bridge for navigations use.

→ There should be adverse environmental input.

Bridge Alignment :—

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

1. **Square alignment** —

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

2. **Skew alignment** —

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

As per as possible, it is always desirable to provide the square alignment.

The skew alignment suffers from the following disadvantages:-

- A great skill is required for the construction of skew bridges. Maintenance of such type of bridges is also difficult.
- The water pressure on piers in case of skew alignment is also excessive because of non-uniform flow of water underneath the bridge superstructure.
- The foundation of a skew bridge is more susceptible to scour (search throughly) action.

At certain locations to avoid costly and unsafe approaches it becomes essential to provide skew alignment. On such, locations the following points are kept in mind.

- There should be smooth entry and exist of water underneath (situated directly below) the skew bridge.
- The skew alignment should not be curved. It is difficult to construct and maintain the curved bridge. The curved bridge has to resist an additional force due to centrifugal action. It is always necessary to arrange piers parallel to the axis of river.

Waterway:-

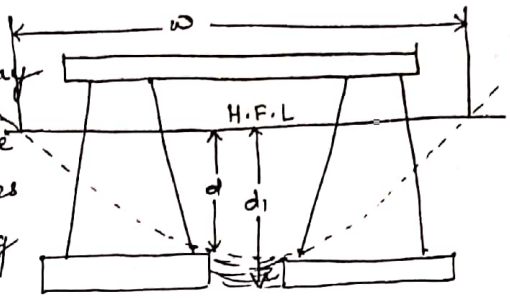
The waterway may be defined as the area of opening under the bridge which should be sufficient to pass the maximum flood discharge that would ever pass under the bridge without increasing the velocity of flow beyond permissible limit, for determining the waterway following should be known.

* Maximum expected flood discharge which will pass under the bridge.
* Maximum permissible velocity. Generally maximum velocity should not be allowed more than 3 m/sec.

$$\text{Area of waterway } (A) = \frac{Q}{V}$$

* Linear waterway in alluvial soils can be obtained from Lacey's Regime Formula as given below,

$$w = c\sqrt{Q}$$



Where, w = Regime width of waterway

c = A constant whose average value is 4.8, but it varies from 4.5 to 6.3 according to local condition

Q = Designed flood discharge in m^3/sec for wide alluvial streams the stable width. w can be taken as by the equation

$$w = 4.8\sqrt{Q}$$

Permissible River Velocity in Different Soil

SL No.	TYPE OF SOIL	PERMISSIBLE VELOCITY m/sec
1.	Clayey soil	1.5 - 2
2.	Sandy Clay	1 to 1.50
3.	Fine Sand	0.60 to 0.90
4.	Softstone or gravel	1.5 to 1.7
5.	Medium Stratified Stones	1.8 to 3.0
6.	Hard Stone bed.	3.0 to 6.60

Flood Discharge:—

The flood discharge is the maximum flow which could be expected to occure at the bridge site during the design period of the bridge.

India Road Congress has recommended that the flood discharge should be determine by a consideration atleast the following two factors :-

(a) From the rainfall and the other characteristics of the catchment.

(b) From the hydraulic characteristic of stream such as cross-sectional area and slope of stream, etc.

(c) From the records available if any of the discharges observed on the stream at the site of the bridge or at any other side in its vicinity.

$$\omega = 4.8\sqrt{Q}$$

Economic Span :-

When the site for a bridge is fixed with reference to clear waterway, flow of water, alignment or road or railway, etc, the length of each span will have to be decided keeping in view the depth of the foundation, height of pier and the nature of the river bed at the site of the bridge. The span for which the total cost of the bridge will be minimum is known as economic span of the bridge.

The length of each span depends on :-

(a) the nature of river bed.

(b) the depth and type of foundation required.

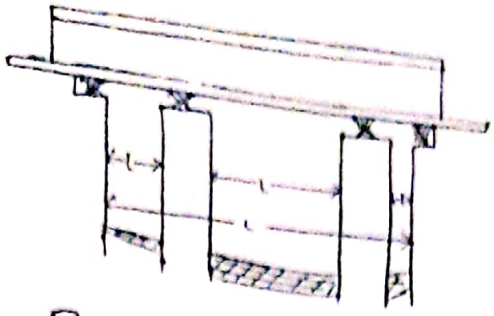
(c) the height of the pier required.

(d) Nature of waterway or bridged or crossed.

(e) The conditions under which the structure is to be constructed.

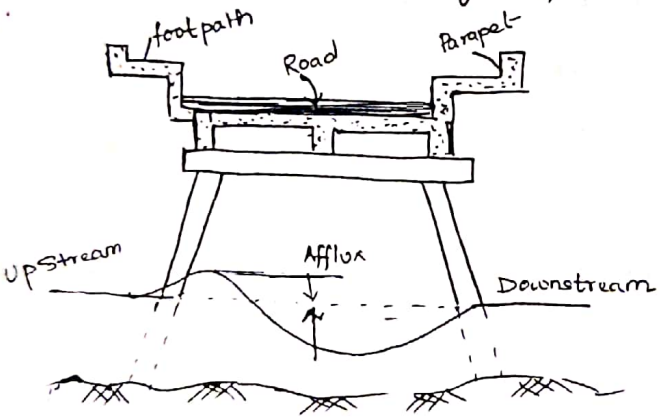
(f) Nature of the available construction materials for the bridge

Availability of the skilled labour in the locality



AFFLUX OR BACKWATER :-

- It is the rise in the level of the water surface of a water course above the normal on the upstream side of a bridge. This rise is due to the obstruction caused by the bridge abutments and piers in the flow of the water
- Afflux is taken as the difference of levels of the downstream and upstream water surface of the bridge.
- The natural water-way of the rivers or streams width is in excess of that required for the regime of the alluvial rivers, therefore water-ways below the bridges are always kept less for the purpose of stability.



Afflux haps in :-

(i) Determining the regime of the streams channels or rivers upstrea of the bridge.

ii) Determining the height of propective and river training works.

iii) Determine the height of the underside of the bridge. Due to

Due to the following reasons afflux should be kept as low as possible:—

(a) If the afflux is greater, it will increase the velocity of water in the downstream which will cause more scour and deep foundation will be required.

(b) When afflux is more, the water level will be high and this will submerge more area of land, therefore high and long wide banks will be required for protection works, causing increase in cost.

Free board:—

→ It is the vertical distance between H.F.L (high flood level) of the river and the bottom level of grinder/springing level in case of arch bridges.

→ Free board is provided to pass the fallen trees, ranks and other similar debris at the time to high flood in the river under the bridge above the highest flood level.

→ To accomodate the afflux due to contraction of waterway during maximum flood discharge.

Otherwise the water will strike the structure at the bridge and there may be chances of its damage.

Clearances:—

For the free passage of the vehicles in the bridges, horizontal and vertical clearances are provided to protect the vehicles from striking the bridge structure.

In case of bridge constructed on a horizontal curve with a superelevation road surface the horizontal clearance must be increased on the inner kerb side by an amount equal to 5m multiplied by the value of super elevation. The minimum vertical clearance distance should be measured from the super-elevated side of the road.

for a roadway it's 16.5 feet
for a bridge over a rail road track it's 23.5 feet
minimum vertical clearance

CH-9

Scour depth minimum depth of foundation

The depth of the well foundation should not be less than 1.33 times the deepest scour depth below HFL - further as per IRC-:, the foundation should be taken at least 2m below the max^m scour depth for piers and abutments with arches, that is the minimum grip length in such cases is 2m.

Types of Bridge

1. Beam Bridge
2. Truss Bridge
3. Cantilever Bridge
4. Arch Bridge
5. Tied Arch Bridge
6. Suspension Bridge
7. Cable-Stayed Bridge

Design data of bridge:—

The following data should be collected for proper design and construction of mazor bridge:—

1. General data
2. Catchment area & runoff data.
3. Data regarding nature of ~~steel~~ soil.
4. Data regarding alignment and approaches.
5. Superstructure data.
6. Foundation data.
7. Data of existing structure.
8. Miscellaneus data
9. Substructure investigation.

Types of Foundation:—

Shallow Foundation

- Shallow foundation are the foundation which are provided at strong soil in available at low depth.
- Terzaghi has limitted the depth of shallow foundation as

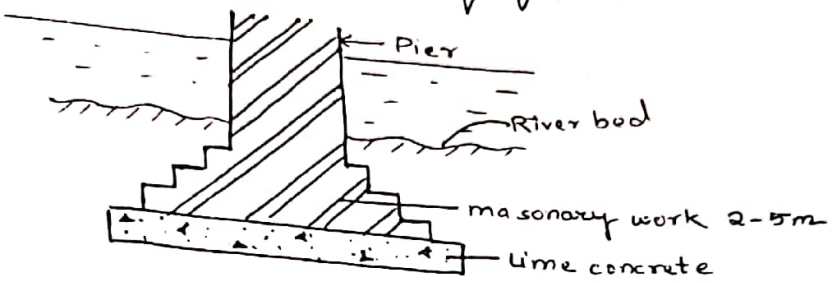
$$\frac{D}{B} \leq 1.$$

However, the depending upon the type of soils and also an the situation of load transfer. The shallow foundation can be classified as following types:—

1. Open foundation / spread foundation
2. Raft foundation
3. Pile foundation
4. Well foundation
5. Cassion foundation

Open Foundation :—

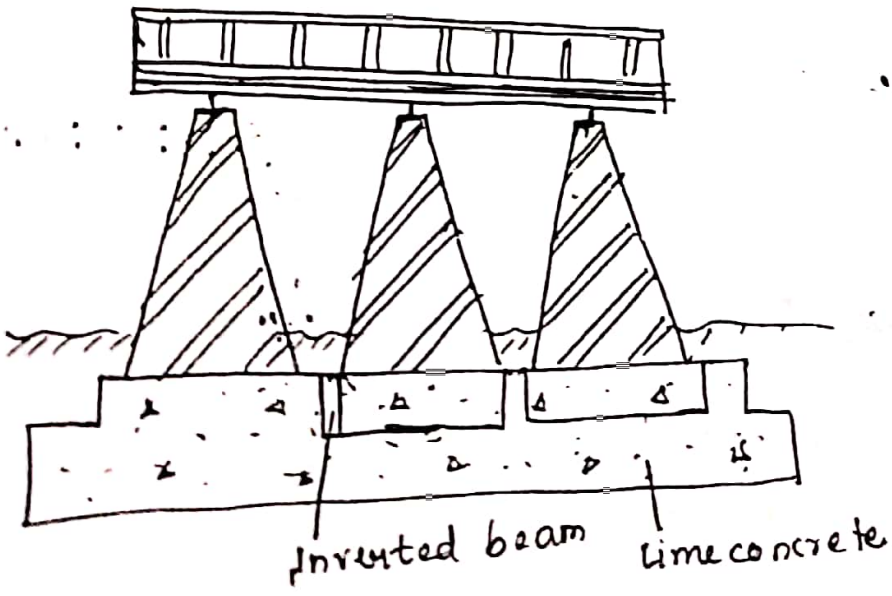
- If the good and hard soil is available within 2-5 mts below the bed level of the river, spread foundations are provided.
- This type of foundation is best suited at such places where scouring.
- The base of the pier or abutment is enlarged or spread to provide individual support.
- This type of foundation can also be provided under piers, which are constructed on dry sand having good soil.



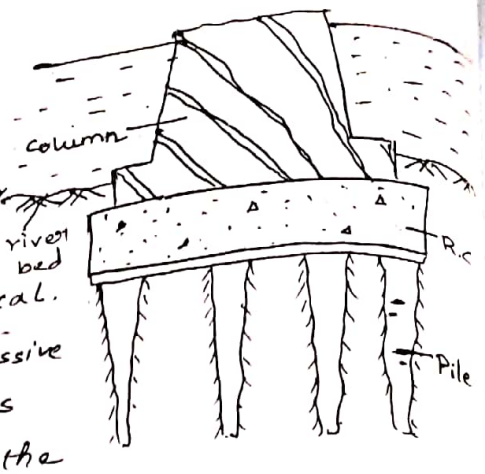
Raft Foundation :—

- When the river bed consist of different types of soils having less bearing capacities raft foundation is provided.

This type of foundation is provided when bed contains soft clay and good soil is not available within a resonable depth of 1·5-2·5m.



Pile Foundation:—



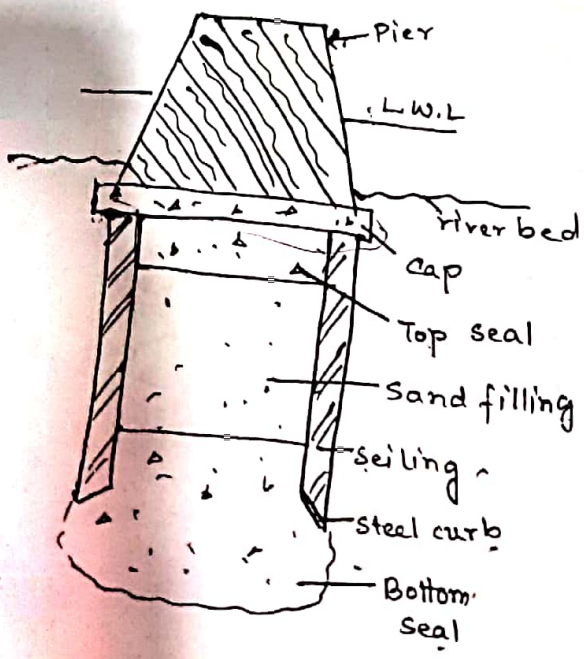
- If the soil at the side of bridge is very soft and good soil is at a greater depth pile foundations are provided because circumstances these are economical.
- When the load on a foundation is excessive and heavy, and other types of foundations are uneconomical, the pile foundation is the only alternate.

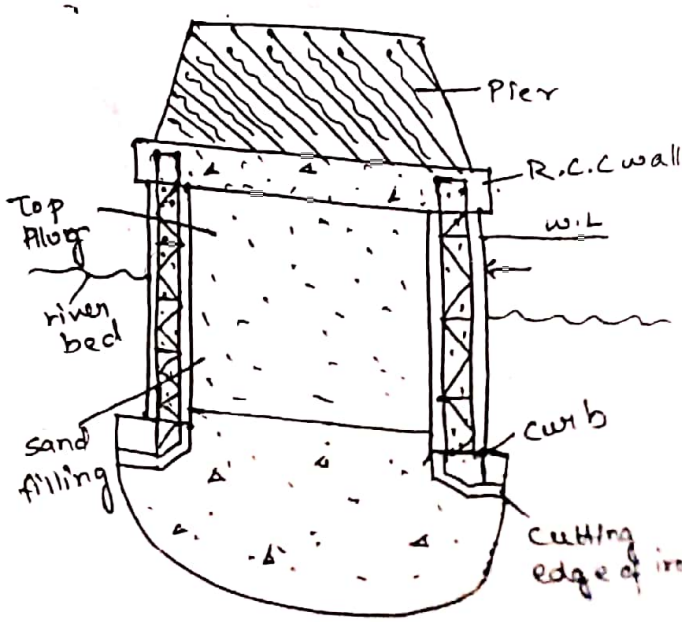
(iv) Well Foundation:—

- When the good soil is available at nearly 3 meters below the bed level and bed consists of sand, well foundations are provided.
- These are used in soft soils or sandy beds where scouring is liable to occur. Well foundations are provided to distribute excessive load of the bridge.

(v) Cassion Foundation:—

- When the depth of the water in the river is more and good soil is available near the river bed, cassion foundation are provided.





Pile Driving :—

The method which force the pile into the ground upto the required depth are known as pile driving methods for driving the piles, hammers, loads and winches & pile frames are required.

Pile Frame :—

It is a steel structure frame whose height varies from 10-25m

Pile Hammer :—

The hammer which give blow at the top of the piles for driving them are known as pile hammer.

(a) Drop hammer
(b) Single acting stream hammer.
(c) Double acting stream hammer.
(d) Differential acting stream hammer
(e) Diesel hammer
(f) Vibrators hammer

Leads :—

The hammer is guided between two parallel steel member is kl' as leads.

Winches :—

- These essentially consist of steel drum, wire ropes and pulleys tilted at the top of the pipe frame
- These are used in lifting & lowering the piles frame and hammer for keeping them in position.

Mathematically, $WH = RS$

W = wt. of the hammer.
H = H.F of the fall.
R = pipe capacity
S = Pile penetration of the last blow

$$Ra = \frac{1}{6}\left[\frac{12wft}{stc}\right] = \frac{2wft}{stc}$$

COFFERDAM :-

It is a temporary structure which is built to remove water from an area and make it possible to carry on the construction work under reasonable dry conditions, cofferdams are usually required for prosects such as dams, docks and construction of bridge piers and abutments

Requirement of a cofferdam :-

1. The cofferdam should be resonably water tight.
2. The design and layout of a cofferdam should be such that the total cost of construction maintenance, pumping is minimum.
3. It should be sufficiently stable against crusting, overturning and sliding, under the floods, waves and antieipated loads
4. It should be generally constructed at the site of work.
5. It should be so planed to facilated easy dismantling & reuse of materials.

Types of Cofferdams

Followings are some common type of cofferdams.

1. Earth fill cofferdam
2. Rockfill cofferdam
3. Rockfill crib cofferdam
4. Single wall cofferdam
5. Double wall cofferdam
6. Cellular cofferdam

Selection of a Cofferdam

The selection of the type of cofferdam depends upon the following factors :-

1. Extent of an area to be protected by a cofferdam

(iii) The depth of water to be dealt with.
(iii) The possibility of over topping by floods, tides.
(iv) Velocity of flowing water.
(v) The nature of bed on which the cofferdam is to rest
(vi) The possibility of scour due to reduction of waterway caused by construction of cofferdam.
(vii) The availability of construction materials in the vicinity of site of work.
(viii) Transportation facilities available.

Shrinking of well.

In case of well shrinking in dry grounds are open excavation upto a half meter above the subsoil water level is carried out and the well curb is left. In case, the well are to be same in mid-stream, the suitable cofferdams are constructed around the site of the well and islands are made.

hammer :-

Simple wt 1-4 tones lift manual labour through winches.
Fall under gravitational fance from a height of 1.5m - 6m.

Single acting :-

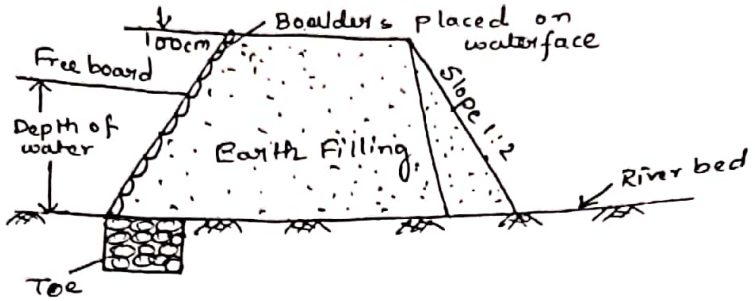
Raise by mean of steam or compressed air & then are allowed to fall under force of gravity on the top of the pile. 60 blows per min.

Double :-

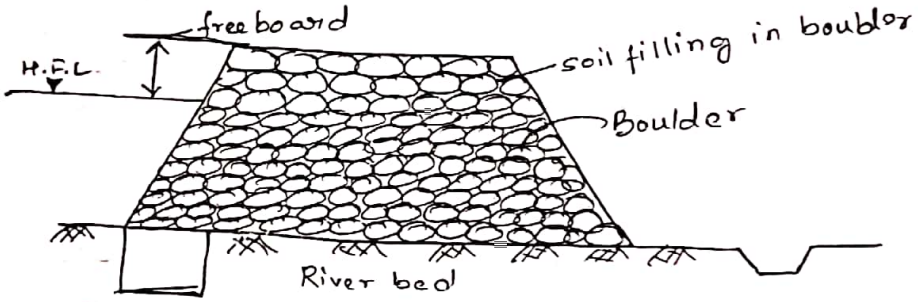
If these hammers, the lifting and dropping both are done by means of steam or compressed air fence.

Vibrating are mainly used for driving sheet piles. These give vibration at high rate to the sheet piles and the same are driven in less than 30 sec upto a depth of about 20m.

Earthen Cofferdam



Rock-fill Cofferdam



Earthfill :—

This is the simplest form of cofferdam it is use in limited in the vicinity where imperveous earth is available & water depth is shallow with low velocity of flow

Rockfill :—

They are constructed by placing rock along stream. They can be used for depth of water upto about 3m and are suitable even in case of swift (rapid) water. They are economical in peaces where rock is available in plenty quite enough.

Pier, Abutment and Wing-wall

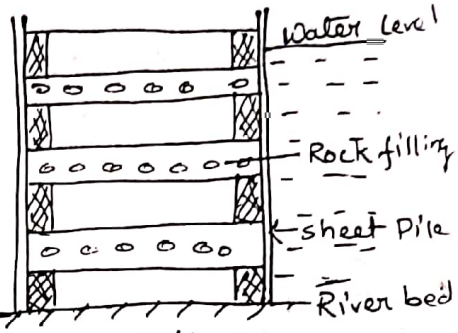
Different types of piers :-

1. Abutment Pier
2. Dumb bell pier
3. Solid Pier
4. Column Pier
5. Trestle pier
6. Cylindrical Pier
7. Pile Pier.

Abutment Pier

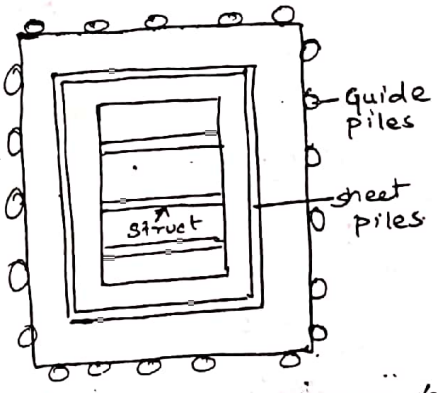
Rockfill Crib Cofferdam

A rockfill crib cofferdam is comprised of timber cribs A cribs is a frame work of wooden horizontal and cross beams laid in alternate courses. The cribs are open at the bottom and are filled with rock/gravel/earth. This gives stability to crib against overturning or sliding.



Single Wall Cofferdam

- This type of cofferdam is suitable when available working space is limited and area to be enclosed is small.
- It is used to the depth of water is which 25m.
- Walls are made of steel sheet pile available to a maximum length of 22m.



Double Wall Cofferdam

Double wall cofferdams are provided to enclosed a large area The double wall gives stability to the cofferdam. This type is useful where scour problems and space limitation are prevalers.

6. Cellular Cofferdam:-

They are made of steel sheet piles and suitable for dealating large areas.

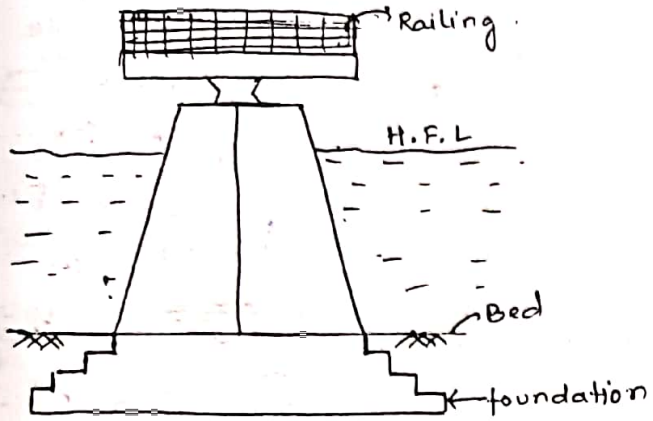
Condition for Cofferdam —

- The stream has a hard bottom
- Working space is limited.
- Depth of water is high.
- Current of water is high.
- There is danger of over topping
- The timber is relatively cheap.

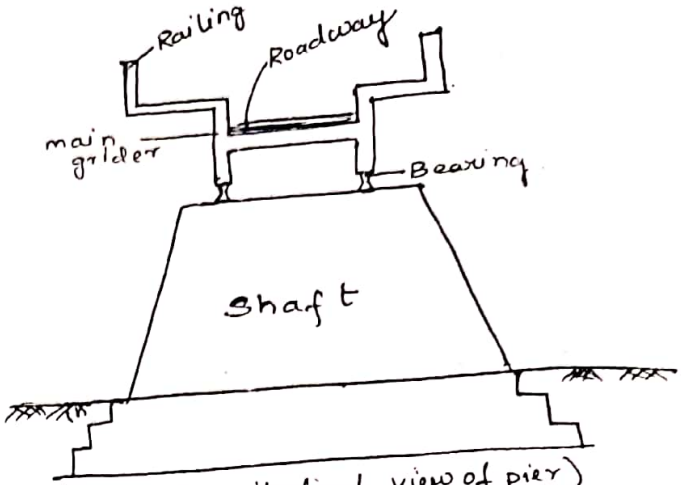
CH-10

Piers —

It is an intermediate support of multispan bridge. Its height is equal to the height of the abutments.



(side view of pier)



(Longitudinal view of pier)

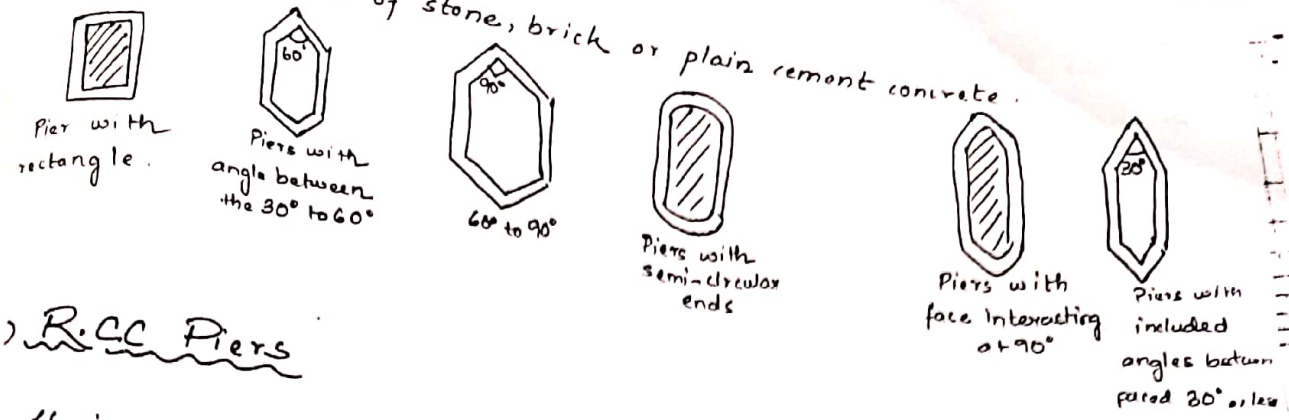
Types of Pier

It may be solid and open type piers are composed of beams columns, solid piers have a solid section in elevation & plan etc.

Solid piers can be classified as (i) Masonary Pier
(ii) R.C.C Pier

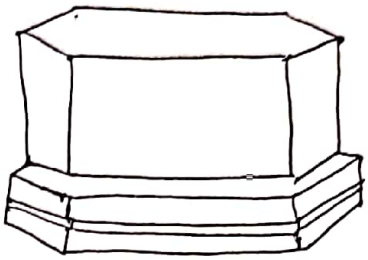
Masonary Pier —

It is constructed of stone, brick or plain cement concrete.



(ii) R.C.C Piers

It is generally rectangular cross-section and do not need bed blocks.



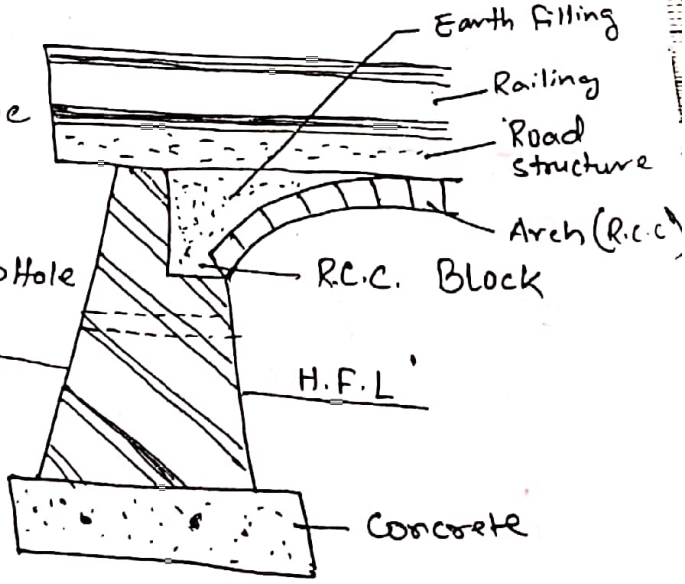
Abutments

The end supports of the super-structure are called abutments.

Function of Abutments :—

The end supports of the superstruture are called abutments.

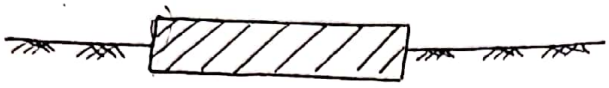
- They transmit the load from the superstructure of the bridge to the foundation.
- They give final formation of the bridge
- They give support & retain weep Hole the earthwork of the embankment of the approaches.
- They serve as pier and retaining wall both.



Types of Abutments:—

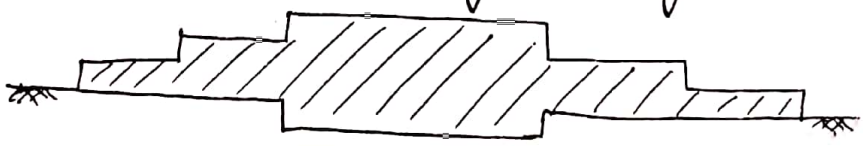
→ Straight abutments without wingwalls.
→ Abutments with straight wing walls.
→ Abutments with splayed wing walls.
→ Tee abutments.
→ Abutments with wing walls at right angles.
→ Pulpit abutments.
→ Hollow abutments.

1. Straight Abutment Without Wingwalls:—



- It is that type of abutments are not generally adopted on water way as the flood water will penetrate through the joint of masonary with the Earthwork into the embankment.
- This type of abutment is suitable when the banks are firm and height of approach embankment is small.

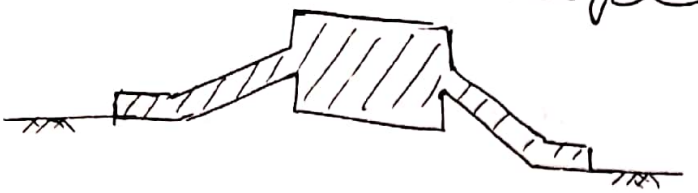
2. Abutments with Straight Wingwalls:—



- It is suitable for railway bridge crossing a roadway or under bridge. It is also suitable when are road crosses another road having lower level.

But this type is not suitable for bridges on rivers, because water may get access in the back of wing walls & damage it, the embankments.

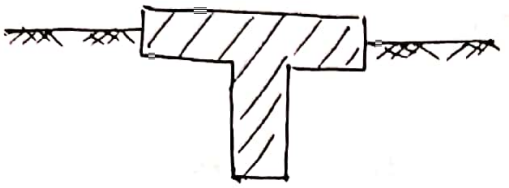
Abutments with splayed wing walls:—



The wing walls are made straight. Its angle may be 45° or 30° with the face of the abutment.

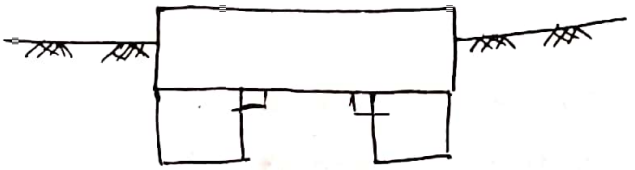
Splayed wing walls prevent damage to embankments of approaches.

4. Tee Abutment:—



- This type of abutments were used in early rail road construction. The head of T-supported the bridge and stem carried the railway track.

5. Abutment with Wingwalls at right angles:—



- The wing wall run back into the fill, which flows down infront of the wings. The wings are parallel to the roadway. The wing walls are tied together with the heep of old rails.
- This type of abutments are suitable where rock slopes make it possible to step up the wing wall footing.

6. **Pulpit Abutment:—**

It is a modified 'U' abutment where the arms of 'U' wing at right angles are made shorter.

7. **Hollow Abutment:—**

- These abutments are curved in plan and are used only in rail and road crossings on land.
- These are mainly provided for economy in certain conditions.

- Sometimes these abutments are provided with curved wing walls.

Abbutment with Wing Walls—

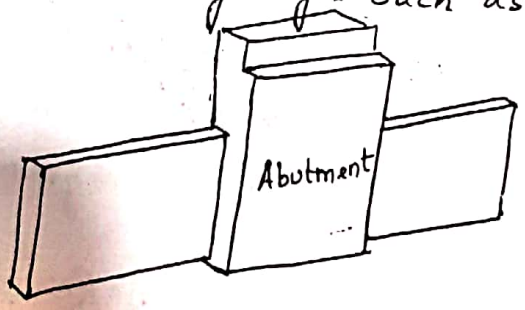
Actually they are retaining walls constructed to retain the Earth-work of the approach embankments behind the abutments.

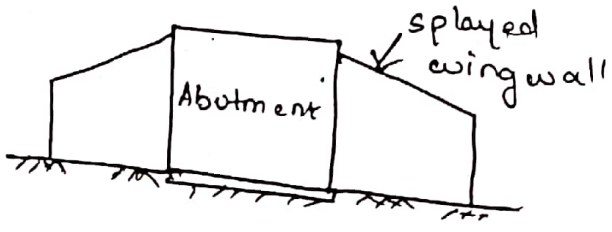
They may be classified as follows:—

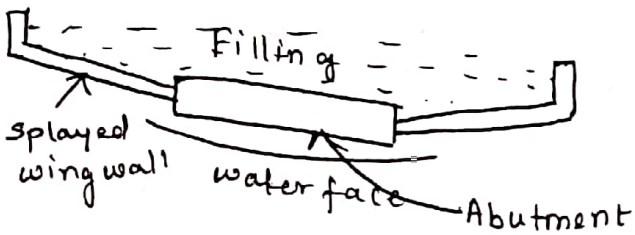
1. Straight Wingwalls
2. Splayed Wingwalls
3. Return Wingwalls.

Straight Wingwalls:—

This class of wing walls specially suited where the cost of land is very high such as for railway bridges in cities.







Splayed Wing Wall

This type of wingwall makes an angle of 45° with abutment.

Condition for this –

- When two or more roads meet at the approach.
- When the road has to be narrowed on crossing the bridge.
- Crossing of a river, as it affects the smooth entry and exit of the current.

3. Return Wing Wall

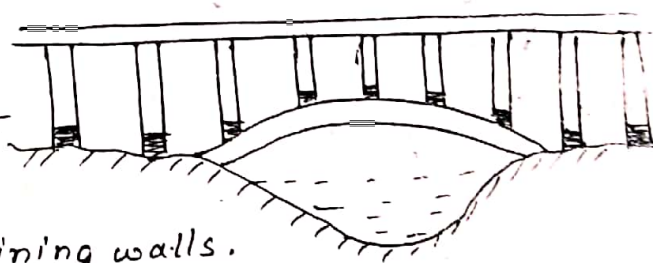
In this class of wing walls, wings are constructed at right angle to the abutments. They are most suited to the situations where the banks are high on both flanks and rocky. It is useful where cost of land is very high.

In some places short turn walls may also be constructed and the sides be protected with rough stone pitching.

Approaches :–

These are railway track or roadway which connect the route with the bridge proper.

It is classified as follows :–



- Approaches with straight abutment or T-abutment.
- Approaches with abutment & retaining walls.
- Approaches running over extended portions of the main bridge

In the first two cases the approaches track is given the same treatm as usual on the other portion of the route.

The road approach will provided with foundation course, base course, wearing coat, beam whereas in railway approach it will be provided with formation; ballast ; sleepers; rails; etc

CH-11 Masonary Bridges

* The superstructure of masonary bridge consists of masonary arch over which the roadway is constructed.
- This arch rests on piers and abutements, which are designed for this purpose.
- In old times masonary was the only alternative for the construction of arches, but now-a-days generally bridges are constructed of R.C.C or steel or prestressed concrete.
- Masonary arches are provided for small bridges and culverts upto a maximum span of 6 meters.
- Masonary arches may be of brickwork, masonary or concrete.

Classification of Arches:-

(A) Depending on the shape of the arch, the masonary arches of bridges can be classified as:
(i) Semi circular arches.
(ii) segmental arches
(iii) Elliptical arches.

(1) Semi-circular arches:-

These are provided at such places where alignment of the road or railway is very high.

(2) Segmental arches:-

- These arches are very easy in construction and are generally employed.
- The proportion of rise to span generally varies from $\frac{1}{11}$ th to $\frac{1}{4}$ th, which increase with the increase in the span.

(3) Elliptical arches:-

These arches provide the maximum waterway. These are light and very graceful in appearance, but their construction is very difficult.

(B) Depending on the way, how these arches support the roadway above their top, these may be classified as-

(a) filled spandrel arches:-
These types are used for small ratio of ratio of rise to span.

b) open spandrel arches:-
when the ratio of rise to span is very large, the spandrel is not filled because this increases unnecessary load on the arch.

Roadway:-
After the construction of arches, the spandrel filling is done with soil over soil filling is thick layer of time concrete is laid and the top is brought to a uniform level.

Requirements of Good Floor of Bridge:-
The following are the requirements of a good floor of bridge

1. It should be cheap in construction and maintainace.
2. It should be strong, durable having long life.
3. It should be comfortable to the traffic, and should provide smooth riding.
4. It should be noiseless when traffic pass over it.
5. It should be such that can be easily drained.
6. It should not give glare to the traffic.

Steel Bridges :-

A cast iron arch bridge of span 30.6 cm was first constructed in 1776.

Now a days much advancement has been done steel bridges and mostly long railway bridge arch constructed with steel.

Classifications of Steel Bridge :-

(1) Steel through plate bridges
(2) Steel girdere bridges.
(3) Steel truss bridge
(4) Bow string bridge.
(5) Suspension "
(6) Steel arch "
(7) Steel rigid frame "
(8) movable "

(1) Steel through plate Bridges :-

- Steel through plate can be used for constructing small bridge upto 5 m. span.
- Steel throughs of sufficient section are laid in the required width of the road and are tied together with steel bars so as to remain in position.

(2) Steel gridere bridges :-

These are ~~used~~ for used for small railway bridge. The truck is directly laid over the griders, which are braced together.

Steel bearing are provided below girding which transfere the load to abutments.

(3) Steel truss bridges:-

- For very long bridges or railway, generally trussed girders of steel are provided because these may have roadways on the top or bottom or on both at the same level.
- Sometimes these are used for combined road and railway bridges.
- This is a stiffed form of structure and ten affected by wind pressure.

(4) Steel arch bridges:-

- Bridges of very long single spans are constructed with steel arches where it isn't possible to construct intermediate pier.
- two-hinged type steel arches are more rigid and economical.

(5) Bow String bridges:-

- In steel-arch bridge the abutments are designed to carry the great thrust caused by the arches on them.

(6) Steel rigid frame bridges:-

- In this type, steel portal frames are used for the construction of bridges.
- The roadway is provided on the top of the portal frames, the corners of which are stiffened for rigidity.
- Steel rigid frame bridges can be constructed in a short time and very economically.

(7) Suspension's bridges:-
- These bridges utilize wire ropes which support the roadway by suspenders.
- The wire-rope or cables are carried over the piers.

imp (8) movable steel bridges:-
- These temporary bridges are also called opening bridges.
- It is bit possible to construct the bridge superstructure at such a level that navigation. ships can pass below the bridge even in high floods.

Movable bridge are different types:-
(i) swing bridge
(ii) Bascule "
(iii) Traversing "
(iv) Transporter "
(v) vertical lift-bridges
(vi) flying "
(vii) cut-boat bridges.

(1) swing Bridge:-
In these bridges one piers is provided in the channel.

(2) Bascule Bridge:-
This is also known as draw bridge and can turn about a horizontal axis and form a vertical direction.

(3) Traversing Bridge:-
These are also called "draw bridges" and can rolled forward or backward across the opening.
These may be operated manually or electrically.

(4) Transporter bridges:-

These consist of a travelling car. This travelling car moves form onesicle of the bank to the otherside in suespended position.

(5) vertical lift bridges:-

In wider navigation canals ore reivers where Bascule swing bridge is it economical. Lift bridge is provided where the navigation boat or ship comes, the main span is lifted.

(6) Flying bridge:-

These are purely temporary bridges, used for crossing streams.

(7) cut boat bridges:-

when the width of the navigation channel is more, it is nit always possible to make the whole boat bridge movable.

R.C.C Bridges:-

* R.C.C has found that it is the best material fore the construction of Engineering structure.
* concrete is verey suitable fore taking compressed loads band steel is more suitable fore tensile loads.
* R.C.C is better than steel because steel is neithere then proof noncoroadible.

Types of R.C.C Bridges:

(1) Slab type:-

- This consits of simply a slab of uniform thickness laid on two substances.
- Its used fore small culverts and bridges. upto a maximum of 18 meterespan in design and construct.

(2) T-beam and slab type:-
- It is used for spans upto 20m.
- The t-beam is simply supported over abutments or piers.
- These type of bridge an more commonly used.
- Now a days for road bridges or canals and railway links.

(3) Rigid frame type:-
- In this type of construction horizontal deck slab is made monolithic with the vertical abutment wall.
- This type of bridges can be provided upto 20m span.

(4) multiple span portal frame type:-
- It consits of continuous spans in which the superstructure is monolithic with the supporting abutments and piers.
- In this type the span limit is 15m.

(5) Girders with vareying moment of inertia type
- This type consits of continuous girder spans having vareying moment of inertia along the span.

(6) Double cantilever type:-
- It is suitable where the bridge has many spans. this bridges are also known as Balanced cantilever type.

(7) Barrel arch type:-
- In this type the arch is constructed monolith with the abutments or piers and is provided with closed spandrels.
- It is suitable for use on spans upto 70m.

* This type of bridges may be three hinged, two hinged, and one fixed barrel type

(8) open spandrel arch type :-

- It is just like Barrel arch type but open spandrel is provided in place of filled spandrel.
- These types of bridges can be used for much longer spans upto 250 meters.

(9) Bowstring girder type :-

* In this case the arch ribs are constructed above the deck level of the bridge.
- This type can be used for long spans upto 100 m.
- The bowstring girders being rigid are not affected even by slight horizontal displacement of the abutments

(10) Hollow girder bridges :-

- These bridges have closed box type cross section of their girder and are economical for spans bet^n 25 to 30 m.

for spans bet 25 to 30 m.

CH-12

Culvert

- It is a small bridge used for carrying water from one side to another side in the embankment of road or railway.
- A culvert may have one, two or three spans.

following four types of culverts are commonly used.

(a) Arch culvert
(b) Pipe "
(c) Slab "
...

(1) Arch culvert :-

- Brick or stone masonary arch culverts were very popular in the previous times but nowadays, these are very uncommon.
- Thus culverts mainly consist of foundation, abutments, wing walls, arch and the parapet.

(2) Slab culvert :-

- Masonary culverts with R.C.C slab are very common these days.
- The design of deck slab or culverts is done for the worst possible effect of R.C.C loading.

(3) Pipe culvert :-

- Pipe culvert are becoming more common due to easiness in construction.
- Hume pipes of various diameters are readily available in the factory.

(4) Box culvert :-

- These culverts mainly consits of one or more no. of square or rectangular opening before passing the water from one side to another.

(5) Steel girder culvert :-

- This type of culvert is only provided for railway.
- wooden sleepers are provided bet^n these girders and the rails.

Causeways :-

- Causeways are also known as Irish bridge or Dip. These are used for crossing over load which are of minor importance.

- Thus causeways are temporary crossings which incouse of time will have to be replaced by permanet bridges.

- The causeway denotes a submersible road bridge across a stream which is designed bed built in such a way that the normal dry weat here flow or river.

causeways are provided under the following circumstances: -

(1) when the depth or water in the stream is very small and seasonal flow is less.

(2) when heavy discharge in streams or water courses come only for small duration, generally not exceeding 12 hours.

(3) when funds are not available for the construction of a high level- bridge.

(4) In hill roads at concave curves, where a no. of small steels, flow in wide bed width.

(5) classification of causeways: -

causeways can be classified as follows: -

(1) Flush causeways
2. Low level ,,
3. High level ,,

1. flush causeways: -

- In this type of causeways only pavement is done in the stream bed and no levents are provided.

- flush causeways are provided in hilly roads, when the maximum depth or water doesn't exceed 1.7m in floods.

2. Low level causeways: -

- In some streams, the depth or water generally remains about 30cm for most of the period

- Small openings of about 30-35cm are provided below the roadway slab, so that the winter and summer discharge can pass through these vents without disturbing the traffic.

(c) High level causeways :-

This is also called as submersible bridge. Submersible bridges are provided in the following types.

(1) when the river has small width with straight reach.

(2) When the floor is sandy, but the good soil available at lower depth.

(3) When the road is less important and the traffic is small.

Requirements of causeways :-

(A) Selection of site. The selection of site for submersible bridge or causeway should be done at the place where,

(i) The width of the stream is minimum.
(ii) It has well defined high banks and.
(iii) The stream has straight reach for a considerable length.

(B) traffic requirement: The causeway should have sufficient width for an least two lane of traffic, 6.7m clear width between the kerb or posts fixed to body or wall.

(C) foundation: A monolithic base is provided over the entire length and width, with sloped aprons and cut-off walls or dwarf wall on both the upstream and downstream sides.