LECTURE NOTE

ON

# RAILWAY & BRIDGE ENGINEERING

## (TH.3)

5TH SEMESTER IN CIVIL ENGG.


PREPARED BY

**Er.SWAGATIKA SAMAL**

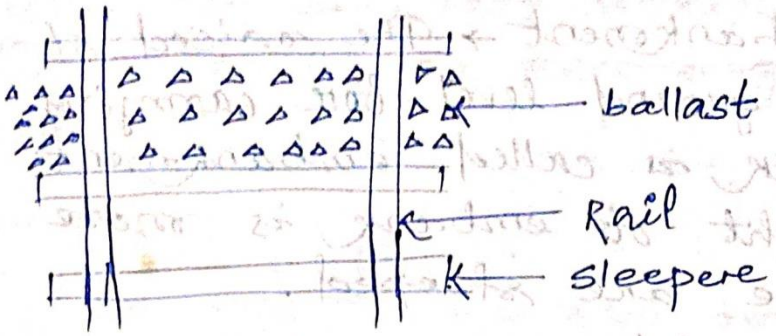
( LECTURER)

DEPARTMENT OF CIVIL ENGG.

G.I.E.T

(POLYTECHNIC),JAGATPUR,CUTTACK,ODISHA

# :- RAILWAY -:




Sleepers → Sleepers are the members laid traversing under the rail, to support the rail & to transfer the load from rail to ballast.

Ballast → Ballast is the granular material packed under and around the sleeper to transfer the load from sleeper to ballast.

Sleeper density → Sleeper density is represent the number of sleeper rail length in metre.

ballast crib → The loose ballast between the two adjacent sleepers is known as ballast crib.

buckling of rail → The railway track get out of the original position then is known as buckling of rail.

Super elevation / cant → On curve to counteract the effect of centrifugal force to level of outer rail is raised above the inner rail by a certain amount. This rising of outer edge over inner rail is known as super elevation / cant.

creep of rail → Creep is the longitudinal movement of rail in track.

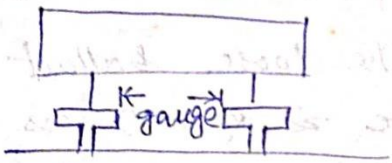
Derailment → Derailment occurs when moving wheel of rail bogie get out of rail. It happens

by an accident and often result in loose of lites or properties damages.

Embankment → The raised structure above the ground level bore carrying the railway track is called embankment when the height of embank is more than side slope are steeped.

Fish plate → These plate resembling in shape to a fish are use to provide the continuity between the two rails at the rail joints. They also provide require gap bore expansion & contraction of rail due to temperature variation. They are made of steel.

Gauge → The gauge of a track in India is measured as minimum distance between the running gauge faces of two rails.




Level crossing → When the rail line & a road cross each other at the same level is called level crossing.

Advantages of Railway →

- Railway have brought about many political social & economic changes in the life of Indian peoples.

Political Advantages →

- Railway have united the people of different cast, religion, custom & tradition.
- With the adequate network of railway the central administration has become more easy & effective.
- Railway have contributes towards development

of a national mentality in the mind of people.
- The role of railway during emergency in war equipment has been very significant.
- Railway have helps in the mass migration of the population.

Social Advantages →
- The feeling of isolation has been removed from the inhabitant of the Indian villages.
- By travelling together into the compartment without any restriction of cast, the feeling of cast difference has disappeared.
- The social outlook of the masses has been broadended through railway journey.
- Railway has make it easier to reach places of religious importance.
- Railway provide a convenient & safe mode of transport of the country.

Economic advantages
- Mobility of labour has contributed to industrial development.
- During famine, railway have play the vital role in transporting food & clothing in affected area.
- Growth of industry has been promoted due to transportation of raw material through railway.
- Speedy distribution of finished product is achived through railway.
- Railway provide employment to million of people & thus help in serving the unemployment problem of the country.
- Land value have increased due to industrial development which ultimately resulting the increase

of national wealth.
- Commercial farming is very much help by the railway network throughout the country.

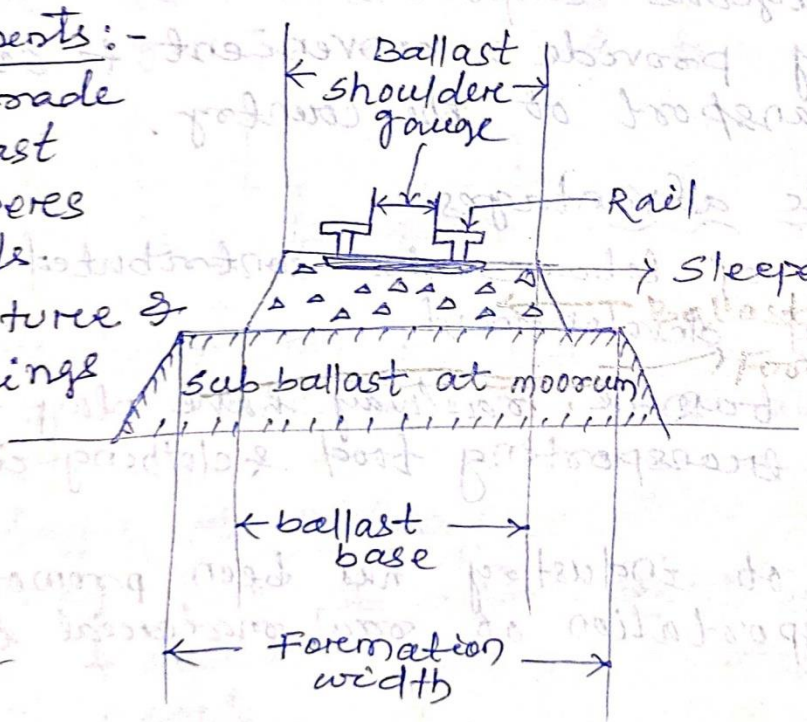
## classification of Indian Railway →

1. Trunk routes.
2. Main line
3. Branch line

## Ch-2 :- Permanent Way :-

The combination of rail, fitted on sleeper & resting and ballast of subgrade is called permanent way or, railway track.

Components :-
1. Subgrade
2. Ballast
3. Sleepers
4. Rails
5. Fixtures & fastenings




## Requirement of an ideal Permanent way →

Following are the some of basic requirement of a permanent way.
- The gauge should be concre correct & uniform.
- The rail should be in proper level.
- In a straight two rail should be at same

level.
- On curve the outer rail should have proper super elevation and there should be proper transition at the junction of a straight & curve.
- The alignment should be correct, that is it should free from irregularities.
- The gradient should be uniform & any change of gradient should be followed by a smooth vertical curve.
- The track should be a certain amount of elasticity in the track.
- The track should enough lateral strength, so that alignment is maintain ever due to
  a. Side thrust on tangent length & centrifugal force on curve.
  b. Lateral force due to, expansion of rail particularly welded rail.
- Super elevation on curve should be properly designed & maintained.
- Drainage system must be perfect.
- Joint, including point & crossing which are regarded to be weekest point of the railway track should be properly designed & maintain.
- If there is trouble from the creep, the precaution should be taken to prevent it.
- The various component of the track that is rail, fitting, sleeper, ballast & formation must fully satisfy the requirement. Then either it should be improve or, replace.
- There should be adequate provision for easy renewal & replacement.

Gauge → The gauge of a railway track is defined as clear distance between the inner or running face of two track rail.

The distance between the innerface of a pair of wheel is called wheel gauge.

Different gauge in India →

- In 18th century the British railway were using the flange on the outside on the rail & the gauge was defined as the distance between the outerface of the rail.
- The gauge then maintain 5 ft. (1.524 m).
- Subsequently the addition of flange inside the wheel gauge change definition of gauge.

Present gauge = Past gauge - 2 x top width of rail

- At present in India the existing gauge are-

| Type of gauge | gauge width |
|---|---|
| 1. standard/broad gauge (B.G) | - 1.676 m |
| 2. Metre gauge (M.G) | - 1m |
| 3. Narrow gauge (N.G) | - 0.762 m. |
| 4. Feeder gauge/light gauge (L.G) | - 0.610 m. |

In India east India company adopted 1.676 m gauge as standard gauge.

- In 1871 ~~in~~ under to built up cheap railway for the development of country the govt. adopted meter gauge. i,e. 1m wide.
- In addition to B.G & M.G in hilly area & bore developing poore area. India has 0.762 m & 0.610 m narrow gauge track & feeder track respectively are used.

Selection of Gauge →

The following factore govern choice among the different gauge.

1. Cost of construction →

- There is middle increase in initial cost if we select a wider gauge. This is due to the following reason.

a. The cost of bridge, tunnel, station building, staff quarter, signal, cabin & level crossing is same for all the gauge.

b. The cost of earth work (in making embankment & cutting), ballast, sleeper, rail etc would proportionally increase in gauge width.

c. There is little proportional increase in occupy of land for permanent track with increase in gauge. We can therefore conclude there is not an appreciable increase in cost due to increase in width in gauge.

2. Volume & nature of traffic →

It is obious that with greater traffic volume & greater load carrying capacity, the train should be run a better traction. or, by better locomotives. For heavier load & high speed, the wider gauge are required because subsequently the operating cost per ton kilometer is less or more carring capacity.

3. Developement of area →

Narrow gauge can be use to develop the thinly populated area by joining poorly developed area with develope or urban area.

4. Physical feature of the country →

Use of narrow gauge in hilly reason where broad gauge & meter gauge aren't possible due to steep gradient. In plane also where high speed isn't required and the traffic

is light narrow gauge is correct gauge.

5. Speed of moment →

- The speed of a train is almost proportional to the gauge.
- Speed is the function of diameter of wheel, which in term limited by the gauge.
- The wheel diameter is generally 0.75 times that of the gauge.
- Lower speed discourage the customer & so for maintaining high speed the broad gauge are preferred.

## Ch-3 Track Material

Rail → The rail on the track can be considered as steel girder carrying axial load.
They are made of high carbon steel to with stand ~~warrentier~~ wear & tear.

Function of Rail →

→ Rail in railway track serve the following purpose -

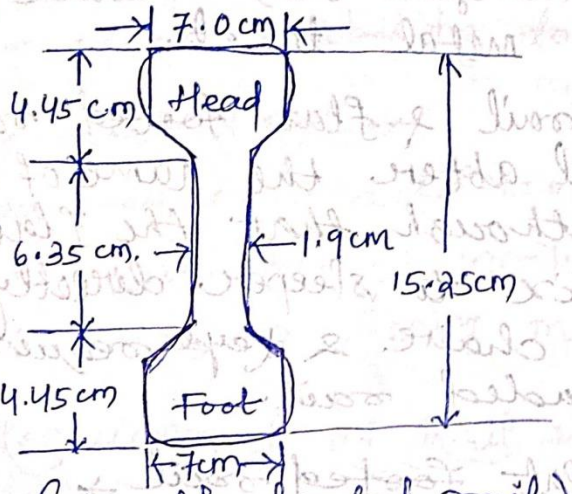
- Rail provide a hard, smooth & unchanging surface for passage of heavy moving load with a minimum friction between the steel wheel.
- Rail bear the stress developed due to heavy vertical load, lateral & breaking force & thermal stresses.
- The rail material is such that, it gives minimum wear to avoid replacement charg & failure of rail due to wear.
- Rail transmit the load to sleeper & consequently reduce pressure on ballast and

formation.

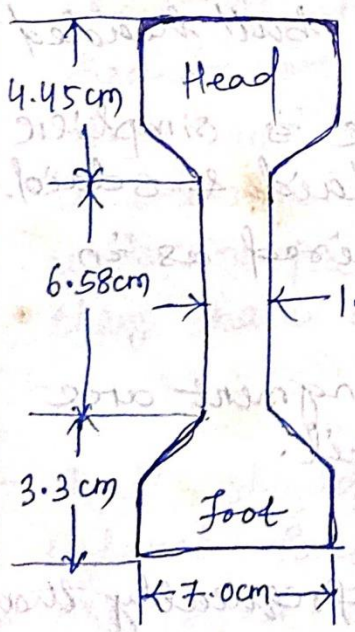
## Types Of Rail Section →

The 3 types of rail section which have been tried so fare for the construction of railway track.

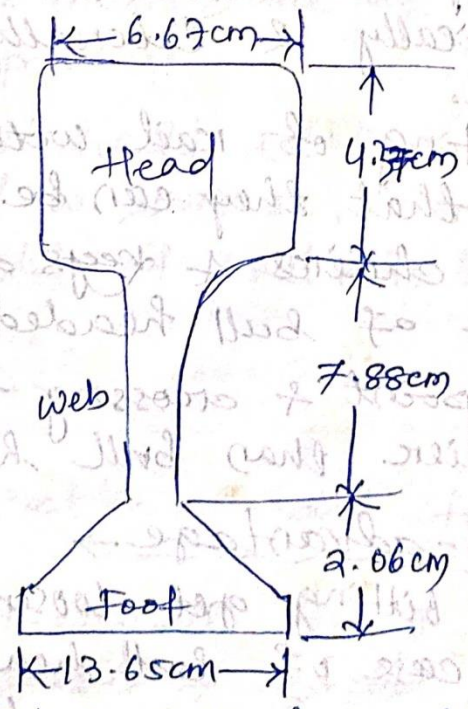
1. Double headed rail (D. H. rail)
2. Bull headed rail (B. H. rail)
3. Flat footed rail (F. F. rail)




(Double headed rail)




(Bull headed rail)




(Flat footed rail)

In the beginning of rail used were double headed of a dumb belled section. The idea behered using the rail was that when the head was worn out in course of time, the rail can be inverted & reuse. But experience show that the lower table formed such indentation that smooth running with that surface of the top impossible.

The next development was that of a bull headed rail, in which the head was made a little thicked & stronger than a lower part by adding more metal to it.

Bull headed rail & flat footed rail is called 'vignole' rail after the name of inventor. It was originally though that the flat footed rail could be fix to sleeper directly & would eliminate chairs & keys required for the bull headed rail.

Advantage of flat footed rail →

- They are more strength & stiffness, both vertically & laterally, than bull headed rail.
- Fitting of rail with sleeper is simpler, so that they can be easily laid & relaid.
- No chairs & keys are required as in case of bull headed rail.
- In point & crossing the arrangment are simpler than bull headed rail.

Dis-advantage →

- The fitting get loosened more frequently than in case of bull headed rail.
- The impact of rooling wheel directly affect the fitting.

- The strengthening of bend rail, replacing of rail & bettered rail are difficult.

Bull headed rail (Advantage) →

- They keep better alignment & give more solid & smoother track.
- The rail are easily disconnected from sleeper as they have no direct connection with the letter.
- The heavy chairs with largere bearing on sleeper give longer life to the wooden sleeper & greatere stability to the train.

Dis-advantage →

- They required additional cost of iron chair
- They have less strength and stiffness.
- They requires heavy maintenance cost.

Requirement of Rail →

- They should be of proper composition of steel & should be manufacture by open heartz ore duplex process.
- The vertical stiffness should be high enough to transmit the load to several sleepere under neaps. The height of rail should be they have adequate

- Rail should be capable of with standing lateral forces.
- The head most sufficiently deep to allow fore an adequate margin of vertical wear. The wearing surface should be hard.
- Web should be sufficiently thick to bear the

load coming on it.
- Foot should be wide enough, so that rail are stable against over turning.
- Bottom of the head & top of the rail foot should be so shaped as to enable the fish plate to transmit efficiently the vertical load from the head to foot of the rail joints.
- Relative distribution of material in head, web & foot of rail must be ballanced
- The centre of gravity of the rail section must be lie approximately at mid height, so that maximum compressive & tensile forces are equal.
- The tensile strength of the rail peace shouldn't be less than 72 kg/mm$^2$.
- The rail specimen should withstand the blow of falling weight in test.

## Length Of Rail →

- The rail of longer length are prefer to smaller length in rail because they give more strength & economic for a railway track.
- The weakest point of a track is the joint between two rail.
- Lesser the number of joint, lesser would be the number of fish plate & this would lead to less maintenance cost, smooth running of train & comfort to the passengers.
- More over the number of joint could increase wear & tear of the vehicle.

Though the long length of the length is desire how ever the rail is govern by the following factor –

a. The length of the rail is so choosen that the manufacturing cost is most reasonable.

b. It depends upon the transportation facility, so only those length of rail are possible which can be transported by longest wagons available on the railway.

c. To some extent the length is also limited by the facility of lifting & handling, during the loading & unloading of wagon.

d. More the length of rail, more will be the gap required for expansion of rail due to temp.

* On Indian railway the standared length are the following -

length = 12.80 m (42ft) for B.G (13 m)
length = 11.89 m (39ft) for M.G (12m)

Rail joints → An ideal perfect rail joint is one which provide the same strength and stiffness as the other rail section of the track

Requirement →

- The two rail ends should remain done in the line both laterally & vertically when train move on the track.
- This is necessary to avoid wheel jumping or changing its correct path of movement.
- The rail joint should be as strong as stiff & the rail itself & should be elastic both laterally & horizontally.
- The rail joint should provide space for expansion & contraction for accord the temperature variation.
- A good joint should be easily disconnectible so that it can be easily taken, but without disturbing the whole track.
- It shouldn't allow the rail ends to get battered in any case.

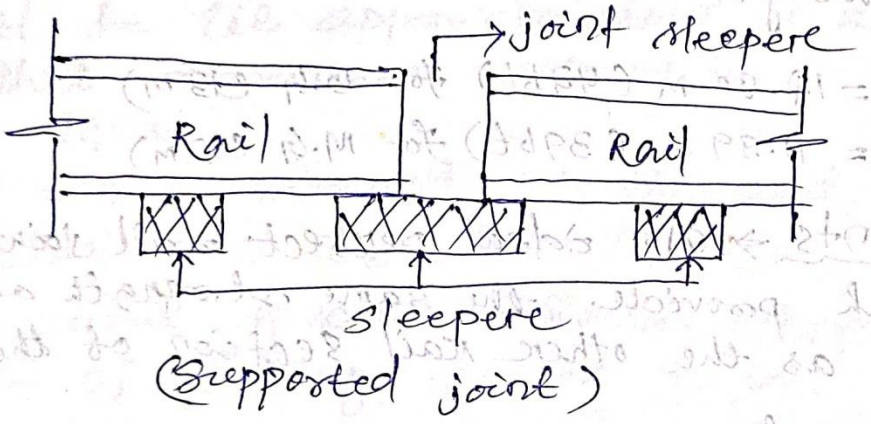
- The joint should fulfill the above requirement with the minimum, initial & maintenance cost. i.e, it should be economical.

## Type of Rail → (Joints)

The following joints are used on Indian & foreign railway.

1. Supported rail joints →

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

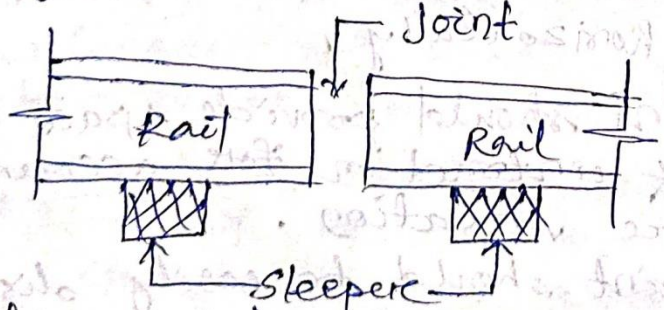



(Supported joint)

2. Suspended rail joint →

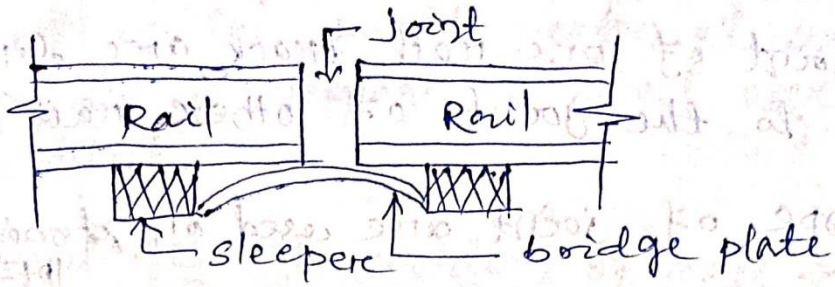
→ When rail ends are projected beyond sleepers called shoulders sleepers, it is called as suspended joint.

→ This type of joint is generally used with timber / steel through Indian & foreign railway.




3. Bridge joint → When the rail ends are projected beyond the sleeper as in case of suspended joint and they are connected by

flat/corrugated plate called bridge plate, it is called as bridge joint.



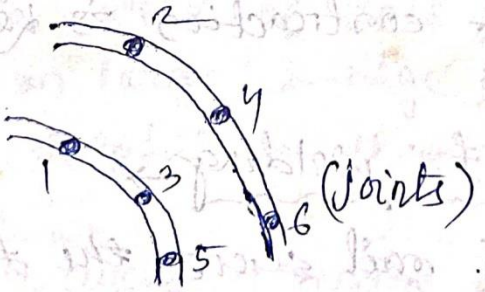

4. Base joint → This is similar to the bridge joint, with the difference that the inner fish plate are of bar type ore outer fish plate are of special angle type. Due to complicated design this is not generally used.

5. Welded Rail joint → These are best joint as they fulfill nearly all the requirement of ideal/perfect joint.

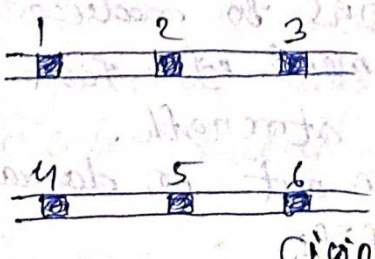
6. Staggered/ broken joint →

→ In this position of joint of one rail track aren't directly opposite to the joint of othere rail track.

→ The joints are generally provided on curve, where the length of outer curve track is greater than inner curve track.




7. Square/even joint →



- The position of rail joint is the basis of its nomenclature.
- The joint of one rail track are directly opposite to the joint of other rail track.
- This type of joint are used on straight track.

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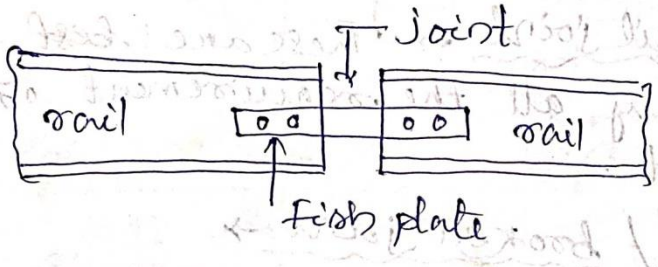
8. Compromize joint → Where two different rail sections are required to be joint together, it is done by means of fish plate which fit both the rails & this joint is termed as compromized joint.




9. Insulated joint → When insulating medium is inserted in a rail joint to stop the flow of current in track. It is called insulated joint.

10. Expansion joint → In bridge, provision for expansion & contraction is kept for girders & rail both.

Purpose of welding →

Welding of rail serve the following purposes,

1. To increase the length of rail by joining two or more rail. & thus to reduce the number of joint & requirement of fish plate, which lead to economy & strength.
2. To repair the worn out or damaged rail & thus increase there life.

3. To build up worn out points & rail on the sharp curve.
4. To build up the burnt portion of the rail had caused due to sleppage of wheel over rail or, other defect.

## Advantages of welding of rail →

1. It satisfy the condition of perfect joint & hence increases the life of rail & reduce the maintenance cost by about 20 to 40%.
2. It reduces the creep as the length of rail increases & friction as a result is also increase.
3. Expansion effect due to temp$^r$. is also reduce which also reduce creep.
4. The discontinuity of joint as a source of weakness in track is reduce. This defect such as hammering of rail joints, displacement of joints, disturbance in allignment & running surface which result in belt riding & eliminated.
5. Long rail have dampen the intensity of high frequency vibration due to moving loads.
6. Welding increases the life of rail due to decrease in the weare of rail.
7. Welded rail on large bridge for the length of span are helpful as they give better performance.
8. Welded rail on curve is under investigation. Maximum curve radius may be welded depending upon resistance & lateral displacement of rail.
9. The cost of track construction by welding of rail decreases due to less number of rail joints.

chapter-7 :- BRIDGE :- section-B

A structure which communication route for carrying road traffic or other moving loads over a obstruction serch as river, stream, canal, road or railway. The communication route may be railway track, road way, cycle track, foot path or combination of them.

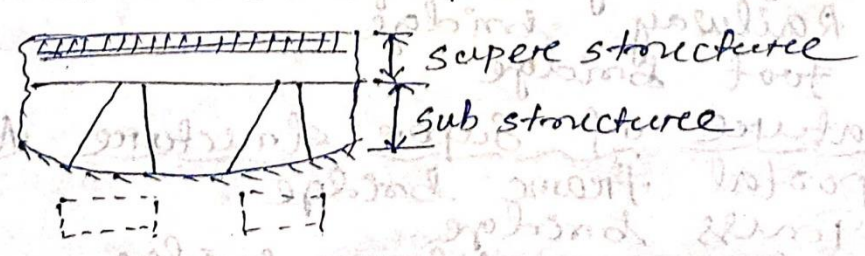
Components of Bridge →

Bridge can be devided into two majore parts.

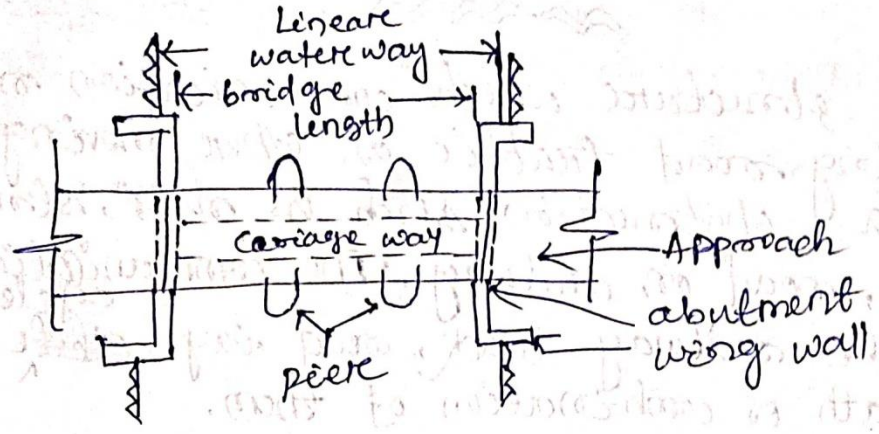
1. Supere structuree
2. Sub-structuree

The supere structuree of a bridge is analogos to a single story building which is sub structue to that of walls, column & foundation supporting it.

1. Supere structuree → It consists of the following parts - (a) hand rail
   (b) beam
   (c) girdere
   (d) Arches & cable above the level of bearing
2. Sub structuree → It consists of the following parts -
   (a) abutment
   (b) peere or abutment peere
   (c) wing wall.
   (d) Foundation for the peere & abutment




(Elevation)




Classification of Bridge →

It is various types depending upon the following factores –

1. Materials used for construction →
   (a) timbere bridge
   (b) Masonry bridge
   (c) Steel bridge
   (d) Reinborced cement concrete bridge
   (e) Pre-stressed bridge
   (f) Composite bridge.
2. Allignment →
   (a) ~~step~~ straight bridge
   (b) skew bridge
3. Location of bridge floore →
   (a) deck bridge
   (b) semi through bridge
   (c) Through bridge.
4. Purpose →
   (a) Aqueduct
   (b) Viaduct
   (c) high way bridge
   (d) Railway bridge
   (e) foot bridge
5. Nature of Supere structure Action →
   (a) portal freame bridge.
   (b) Truss bridge
   (c) balance cantilivere bridge
   (d) Suspension bridge

6. Position of high flood level →
(a) Submersible bridge
(b) Non-submersible bridge.

7. Life →
(a) Peremanent bridge
(b) Temporeary bridge.

8. Fix ore movable →
(a) Swinging bridge.
(b) lift bridge.
(c) bascule bridge.

9. Span Length →
(a) Culveret (less than 8m)
(b) Minore bridge (8 to 30m)
(c) Major bridge (above 30m)
(d) Long bridge (above 120m)

10. Degree of redundante
(a) determinant
(b) indeterminant

11. Type of connection → (only for steel bridge)
(a) Pinned or bolted connection bridge
(b) ribated connected bridge.
(c) Welded connected bridge.

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Requirements of Ideal bridge
1. Sabety & convenience.
2. Aestchetically Sound
3. Economical

Selection of bridge site →
1. Suitable, unyielding and non erodable matereial for foundation.
2. The stream at the bridge Beach side should be well defined and as narrow as possible.

3. It should be a straight reach of stream at each side.
4. It should have permanent, straight & high banks.
5. The flow of watere should be in a steady condition & cross current.
6. Minimum obstruction of natureal watere way.
7. Easy availability of labour, construction material & transport fascility.
8. Minimum foundation cost so that no excessive work is to be carried inside the watere.
9. Possible to provide secure & economical approach.
10. Direct alligment of the road.
11. It should be such that, adequet vertical height & watere way is available undere neath the bridge for navigational use.

Bridge Alligment →

Depending upon the angle the alligment can be two types, square alligment → The bridge is at right angle to the axis of the river.

Skew alligment → The bridge is at some angle to the axis of river which is not at right angle.

Dis-advantages of skew alligment →

1. A great skill is required for the construction mentainance of such type of bridge is so debficult.
2. Watere pressure on peer is excessive because of non-uniform flow of watere.
3. The foundation of a skew bridge is more susceptible to spoure action.

Watere-Way → The area through which the watere flow undere a bridge super structure is known as the watere way of the bridge. The lineare measurement of this area along the bridge is known

as the lineare waterway.

Lineare waterway equal to sum of all the eleare span.

Economic Span → The economic span of a bridge is the one which reduce the overe all cost of a bridge to be minimum. The overe all cost of a bridge depends upon the following factores.

1. Cost of matercial
2. Availability of skilled laboure.
3. Span length
4. Nature of stream to be bridged.
5. Climatic & other condition.

Cost of supere structure = cost of sub structure

Scoure Depth → The normal scoure depth is the depth of water in the middle of the stream to an it is carring the peak flood discharge. It depends upon factore like flood discharge, bed slope, direction of flow, bed material, allignmen of piere & its shape & size.

Depth of foundation → It is determined by consideration of the safe bearing capacity of the soil after taking into account, the effect of scour. The bore holes are drawn to determine the adequacy of thickness of the foundation bearing layer of the soil. The minimum depth of foundation,

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

where, $h$ = depth of foundation, (metre)
$P$ = bearing capacity of soil. (kg/m²)
$w$ = specific weight of earth. (kg/m³)
$\phi$ = Angle of internal friction of the soil.

Afflux → When natural surface width is too large then required for stability in that case to carry the maximum flood discharge, the velocity under a bridge increases. This increased velocity gives rise to a sudden heading up of water on the upstream side of the stream. This phenomenon of heading up of water on the upstream side of the stream is known as 'afflux'.

Marriman's formula,

$$h_a = \frac{v^2}{2g}\left\{\left(\frac{A}{Ca}\right)^2 - \left(\frac{A}{A_1}\right)\right\}$$

Molesworth's Formula,

$$h_a = \left(\frac{v^2}{17.9} + 0.015\right)\left\{\left(\frac{A}{Ca}\right)^2 - 1\right\}$$

Where, $h_a$ = Afflux (mt)

$v$ = Velocity of approach (mt/sec)

$A$ = Natural water way area at the site.

$a$ = Contracted area ($mt^2$)

$A_1$ = Enlarged area upstream of the bridge.

$C$ = Co-efficient of discharge. ($mt^2$)

$= 0.75 + 0.35(a/A) - 0.1(a/A)^2$

Clearance → Horizontal clearance should be the clear width & the vertical clearance should be the clear height which available for the passage of vehicular traffic. For super elevated road horizontal clearance equal to 5 m multiplied by the superelevation. Vertical clearance should be measured from the super elevated level of the road way.

Free board → It is the vertical distance between the designed high flood level, allowing for afflux if any & the level of the ground crown of the bridge at its lowest point.