Bridge Engineering

Sem - VII

Site Selection and Investigation:

- The first step in laying out a bridge is selection of its site.
- In order to ensure safety of the bridge structure and achieve economy in its construction a suitable site for bridge must be selected.
- The careful investigation at the preliminary stage avoids many errors at a later stage.

3.2 Factors Affecting Selection of Site of a Bridge:

Following are the factors to be carefully considered while selecting the ideal site for a proposed bridge:

1) Width of river
2) A straight reach
3) Foundations
4) Connections with roads
5) Firm embankment
6) Materials and labour
7) Right angle crossing
8) Velocity of flow
9) Absence of scouring and silting
10) Minimum obstruction to water way
11) Sound, economical and straight approaches
12) Location of river tributaries
13) Availability of sufficient free board

(1) Width of river:

- The width of river indicates length of bridge.
- It is desirable to have well defined and a narrow channel at bridge site as far as possible which will help in providing least possible length of bridge.
- The smaller the width of river, the cheaper will be bridge in its initial cost as well as maintenance cost.

(2) A Straight reach:

- The river should have straight reach over a reasonable long distance on upstream side and downstream side of the bridge site so that the utility of bridge can be maintained for the design period.
- On the other hand the curved reach of river is not desirable as it creates problems during construction and maintenance of bridge.

(3) Foundations:

- The nature of soil at bridge site should be such that good foundations are available at reasonable depth.
- Such type of bridge site will save expense, labour and time required for providing foundation of abutments and piers of the bridge.

(4) Connections with roads:

- The bridge are constructed to connect the road on either side of a river.
- The bridge site should therefore form a proper link between the roads on either side of a river.
- The approaches at the bridge site should be such that they do not involve heavy expenditure.

(5) Firm embankments:

The embankment at bridge site should high, permanent, straight, solid and firm. Such embankments are not disturbed at the time of heavy floods and they do not allow the course of stream to alter.

(6) Materials and labour:

- The site of the proposed bridge should be such that labour construction material is easily available.
- The transport charges for material and labour at the bridge site should be minimum.
- This type of bridge site will provide economy in the cost of construction.

(7) Right angle crossing:

- At bridge site, the direction of flow of water should be nearly perpendicular to the centre-line of bridge. Such crossing is known as right angle crossing.
- This type of site will help in providing square alignment of bridge which will result in easy and economy in bridge construction.

(8) Velocity of flow:

- The velocity of flow at bridge sit should be between the range of non- silting and non scouring.
- This type of site will result in minimum maintenance cost.

(9) Absence of scouring and silting:

There should be no scouring and silting at bridge site, which will result in minimum maintenance cost.

(10) Minimum obstruction to water way:

There should be minimum obstruction to natural water way at the site of bridge.

(11) Sound, economical and straight approaches:

The bridge site should provide sound, economical and straight approaches. In case of curved alignment, the bridge should be on the tangent and not on the curve, since it is difficult to construct and maintain a curved bridge.

(12) Location of river tributaries:

The bridge site should to away from the point of influence of large tributaries as far as possible. As it will help to protect the bridge from the possible harmful disturbances.

(13) Availability of sufficient free board:

- Sufficient free board should be available for the passage of boats, ships under the bridge superstructure if the river is used for navigation purpose.

3.3 Investigation of Bridge Site:

- The careful investigation at the preliminary stage avoids many expensive errors at a later stage.
- The investigation for the major bridges are carried out in following stages:
  a) Reconnaissance stage
  b) Preliminary stage
  c) Detailed survey and project report

(a) Reconnaissance stage:

- In order to find out number of probable sites satisfying the various factors for locating bridge, the entire length of the river within the area to be interconnected has to be studied. And those sites, which satisfy most of the favourable factors, are selected.

- The factors to be studied in this stage are:
  1) Nature of road traffic at the bridge site and estimating the benefits that will occur from the traffic.
  2) Characteristic and hydraulic data of river.
  3) Study of available maps.
  4) Study of problems which will likely to occur during the construction of bridge.
  5) Visit to the various possible site so as to understand the local features also holding discussion with local knowledgeable people.

(b) Preliminary stage:

- In stage one we have find out a number of probable sites satisfying the various factors for locating a bridge.
- In this stage, an attempt is made to bring out in full detail of comparative merits and demerits of the probable sites
- Following details must be obtained for each stage:
  1) Present and future traffic
  2) Construction and maintenance problems
  3) Subsoil Conditions
  4) Availability of skilled and unskilled labour.
  5) Length of bridge and approaches
  6) Nature of flow at site
  7) Availability of construction material
  8) Time required for construction of bridge
  9) Duration for construction of bridge

(c) Detailed survey:

From the number probable sites, the final selection of bridge site is made and in this stage.

- For the selected site detailed investigation is done with respect to.
  i. Ground survey
  ii. Hydrological data
  iii. Soil exploration
  iv. Period of construction
  v. presend and future traffic
  vi. Structural design
  vii. Total cost of construction
  viii. Return on investment etc.

- Finally, the project containing large number of drawing like:
  1) Index map
  2) Countour survey plan
  3) Site plan
  4) Cross section
  5) Catch area map
  6) Soil profile

- And necessary details is prepared, in such a way that the sanction to the project can be issued.

3.4 Bridge Alignment:

- The location of centre line of communication route to be carried by the bridge at selected site is called bridge alignment.
- After the site of bridge is decided, the next step is to set out the centre – line i.e. alignment.
- The following factors should be considered while locating the alignment of a bridge:

1. Square alignment (Square Bridge)

- As far as possible, centre line of bridge should be at right angle to the axis of river.
- This type of alignment is always preferred because it is easy to construct and maintain.

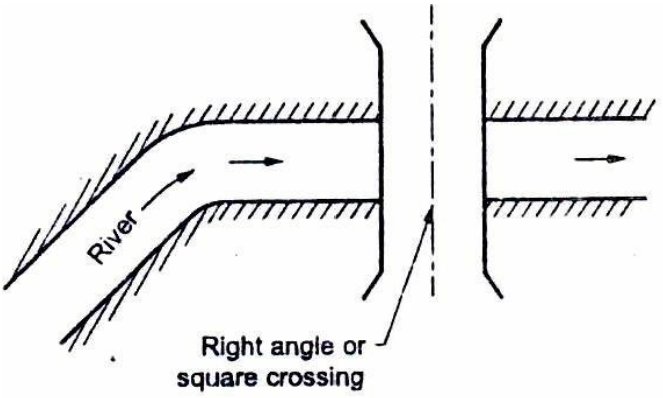


Fig. 3.4.1 : Square alignment

2. Skew bridge:

- As far as possible, the skew bridges should be avoided i.e. avoid skew alignment.
- Since it is difficult to construct and maintain a skew bridge.

3. Curved bridge:

- As far as possible, the alignment should not be skew.
  Since it is difficult to construct and maintain curve bridge.

4. Effects of silting and scouring:

- The necessary precautions should be taken along the bridge alignment to bring down the effects of silting and scouring to be the minimum possible extent.

5. Layout of approaches:

- If the existing road alignment is such that it results in an inclined alignment, the curved approaches may be adopted to form right angle or square crossing as shown in Fig. 3.4.2.

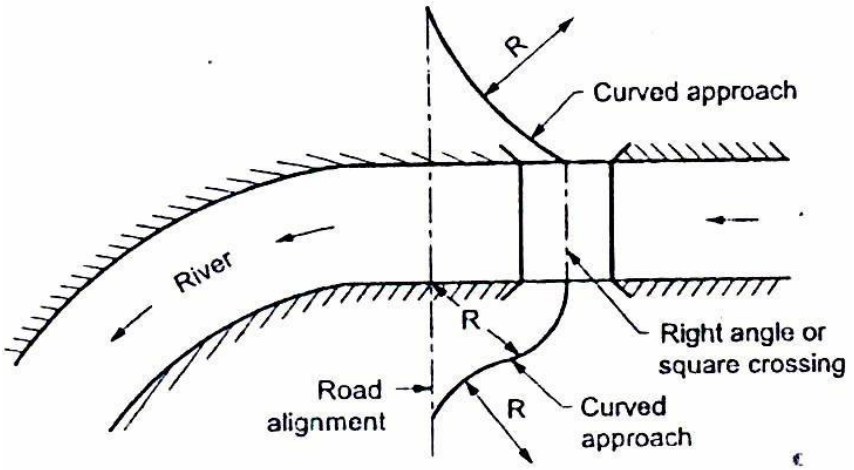


Fig. 3.4.2 : Layout of approaches

3.5 Collection of Design Data:

- The design of a bridge should not be based on guess work.
- As such a design results either failure of structure when built.
- Or the structure becomes un-necessarily costly.
- The following data should therefore be collected for safe and economical design of a bridge:
  a) General data.
  b) Alternative bridge sites and their cross – section.
  c) Hydraulic data of selected bridge site.
  d) Geological data.
  e) Climatic data.
  f) Loading and other data.

(a) General data:

This data should include:

- Maps, plans and topographical features of the proposed bridge site.
- The name of the river and of the road.
- North direction and direction of flow.
- Maximum discharge.
- The alignment of existing and proposed approaches.
- The name of the nearest village or town.
- Width of existing road approaching the bridge.
- Location of all building, nallas, well and other possible obstruction coming in the alignment of bridge.
- Location of longitudinal section and cross section of road as well as of river.

(b) Alternative bridge sites and their cross – sections:

- A bridge description along with reason for selection of particular site should be given.
- Also give cross-section of the channel at alternative sites investigated and rejected.

(c) Hydraulic data of selected bridge site:

This data includes the following information:

- The highest flood level and the year of its occurrence.
  Hydrographs for one or more year.
- Low water level during dry seasons.
  Design discharge and average velocity of flow.
- The slope of catchment both in transverse and longitudinal direction.
  Storage in catchment artificial or natural etc.

(d) Geological data:

This data includes the following information.

- Subsoil conditions.
  Possibility of earthquake disturbances.
- The safe intensity of pressure on the foundation soil.

(e) Climatic data:

This data includes information regarding:

- Annual temperature range.
  Susceptibility to severe storms, etc.
- Wind velocity.
  Rain fall characteristics.
- Relative humidity etc.

(f) Loading and other data:

- Live load for which bridge is designed.
- Nature of road traffic at the bridge site.
- Availability of skilled and unskilled labour.
- Availability of electric power.
- Availability of materials of construction.
- Safety aesthetic consideration etc.

3.6 Classification of Bridges:

Bridge can be classified into various types, depending upon the following factors:

(1) According to function:

a) Aqueducts
b) Viaducts
c) Grade Separations
d) Foot bridge
e) Highway bridges
f) Railway bridges

(2) According to function:

a) Timber bridges

b) masonry bridges
c) Iron and steel bridges
d) Reinforced cement concrete bridges
e) Prestressed concrete bridge

(3) According to span lenth:

a) Culverts
b) Minor bridges
c) Major bridges
d) Long span bridges

(4) According to alignment:

a) Straight bridge
b) Skew bridge

(5) According to the position of HFL:

a) Submersible bridge
b) Non- submersible

(6) According to the size:

- The classification of bridge with reference to the size has been done differently in our country by the road and rail engineers.
- According to the road engineers, the bridge are classified on the basis of lineal water way as follows:
  a) Culvert: upto 6m.
  b) Minor bridge : 6m to 30 m.
  c) Major bridge : over 30 m.

- According to the Indian Railways the bridges are classified as follows:
  a) Major bridges: Total water way more than 18 m or having any span of clear water way of 12 m or over.
  b) Minor bridges : Total waterway less than 18 m or having any span of clear water way less than 12 m.
  c) Important bridges: Those major bridges having total waterway of 18 m and more or more the 110 m.

(7) According to loading:

a) Class 'AA' bridges
b) Class 'A' bridges
c) Class 'B' bridges

(8) According to life:

a) Temporary bridges
b) Permanent bridges

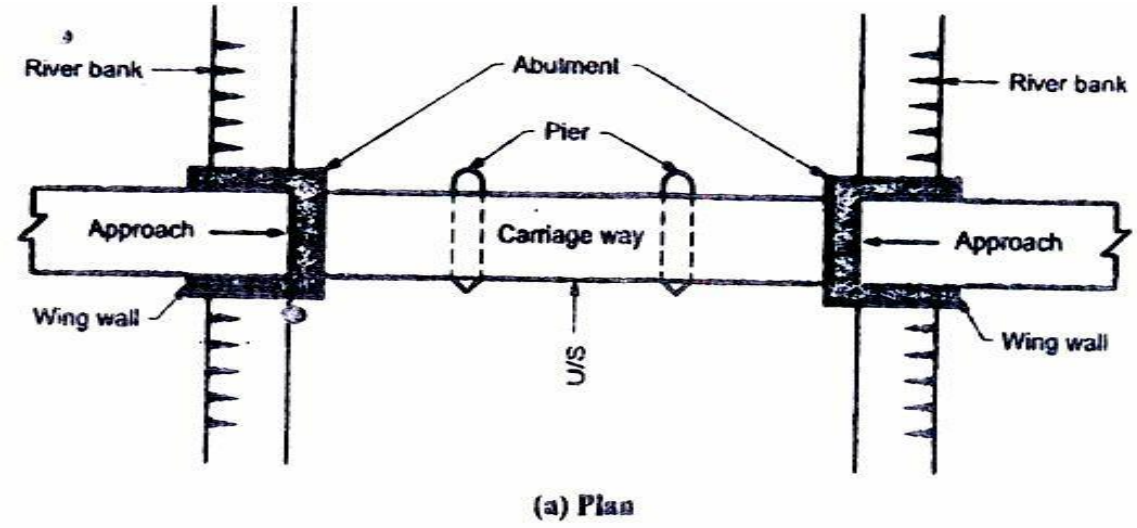
(9) According to the level of bridge floor:

a) Deck bridge
b) Semi through bridge
c) Through bridge

(10) According to the structural form:

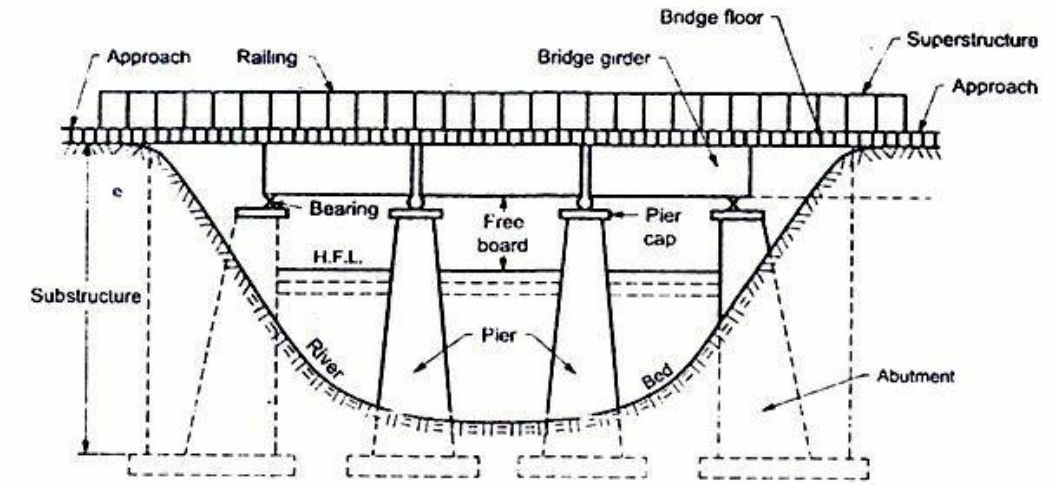
a) Beam tupe bridge : such as R.C.C. tee beam, balance cantilever, steel girder etc.
b) Arch type bridge: Such as barrel and rib type, filled spandrel etc.
c) Suspension type bridge

3.7 Component parts of Bridge:

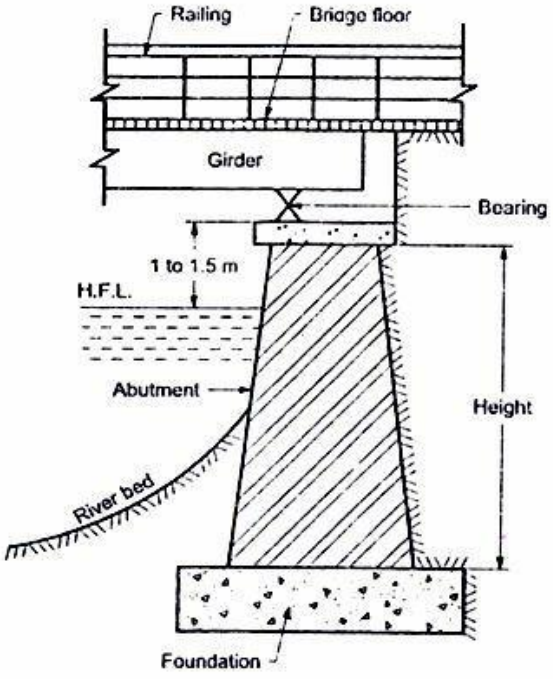


(a) Plan

Fig. 3.7.1 : Components parts of a bridge



(b) Section



(c) Showing component parts of an abutment

Fig. 3.7.1 : Components parts of a bridge

3.8 Important Technical terms:

1. Effective span of bridge:

The center to center distance between any two adjacent supports of the bridge superstructure is called span or effective span of bridge (distance may be abutment and pier or between two piers).

2. Clear span:

The clear distance between any two adjacent support of the bridge superstructure is called clear span.

3. Economic span:

The span for which, total cost of bridge is minimum is called economic span.

4. Water way:

The sectional area at the site of a bridge through which water flows is termed as waterway.

5. Afflux:

The maximum increase is water level due to obstruction in the path of flow of water is called as afflux.

6. Scour:

The vertical cuttion of river bed is called scour.

7. H.F.L.:

The level of the highest flood ever recorded or the calculated level for the highest possible flood is called Highest Flood Level (H.F.L.)

8. Free board:

The difference between the highest flood level after allowing the afflux if any and the lowest point on the underside of the superstructure is called free board.

9. Total span:

The centre to centre distance between the abutments of a bridge is termed as total span of bridge.

10. Curtain wall:

It is a thin wall used as a protection against souring action of a river.

11. Scour depth:

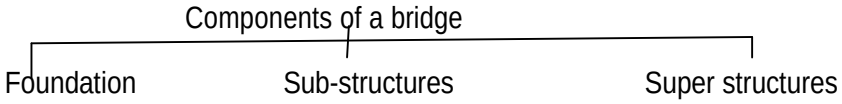
The depth upto which a flowing stream erodes soil is known as scour depth.

12. Length of a bridge:

The overall length measured along the centre line of the bridge from end to end of the bridge deck is called length of bridge.

3.9 Component parts of Bridge and their Functions:

The components of a bridge can be split up into three parts namely:



3.9.1 Foundations:

- The lowermost part of bridge structure is called foundation or.
- The component designed to carry the total weight of the bridge are known as foundation.

- Almost all parts of bridge substructure such as abutments, wing walls and piers rest on foundation.

- **Functions of foundations:**
  1) To take the load of bridge.
  2) To distribute the load of abutment, pier etc over a larger area.
  3) To prevent tilting and overturning of the abutments and piers.
  4) To provide base to the bridge structure.
  5) To provide stability to the bridge on the whole.

- **Types of foundation:**

Bridge foundation can be divided into following categories:

I. Land foundation

II. Foundation constructed in soil charged with water or having water at shallow depth.

III. Under water foundation.

I. Land foundation:

1) Foundations which are constructed on dry land are known as land foundations.
2) It is easy to construct such type of foundation as they are mostly shallow.
3) Also no need for special provision for their construction.
4) These foundations are further classified into following types:

- Spread or open foundation
- Raft foundation
- Inverted arch foundation
- pile foundations

II. Foundations constructed in soil charged with water or having water at shallow depths:

If suitable arrangement is made to exclude the water from the foundation site. Then construction of such foundation is similar as land foundation.

III. Under water foundations:

- The bridge foundations constructed under water are known as under water foundations.
- This are considered as deep foundation.
- Such foundations are difficult to construct.

- Special provisions of cofferdams are made to exclude water from the foundation site.
  Types of underwater foundations:
  (a) Well foundations (b) Caisson foundations

3.9.2 Substructures:

- The lower part of the bridge consisting of structural system in the form of abutments, piers, etc. along with their foundation which supports the superstructure is called substructure.

- Function of substructure:
  1. To support superstructure.
  2. To provide access to the traffic to the level of bridge superstructure through approaches.

- Substructure of bridge consists of following components:
  I. Abutments
  II. Piers
  III. Wing walls
  IV. Approaches

I. Abutments:

- **Definition:** The end supports of a bridge superstructure are known as abutments
  (Refer Fig. 3.7.1(c))

- **Functions:**
  1. To support the superstructure.
  2. To transmit the load of superstore to foundations.
  3. To provide final formation level to the bridge superstructure.

- **Types of abutments:**
  Bridge abutments are of following types, according to their layour in plan:
  1. Abutment without wing walls
  2. Abutment with wing walls

1. Abutment without wing walls:

These abutments are suitable when:
  a) Bank of river at bridge site is sufficiently firm
  b) Velocity of flow of river water is less
  c) There is no danger of side erosion.

- **Types:**
  When the abutments are without wing walls, they may be of following types:
  a) Straight abutment
  b) Tee abutment
  c) Hollow or arch abutment

(a) Straight abutment:

- The abutment usually rectangular in plane are known as straight abutment.

- Such abutment will be useful for bridges without waterway or with negligible water way.

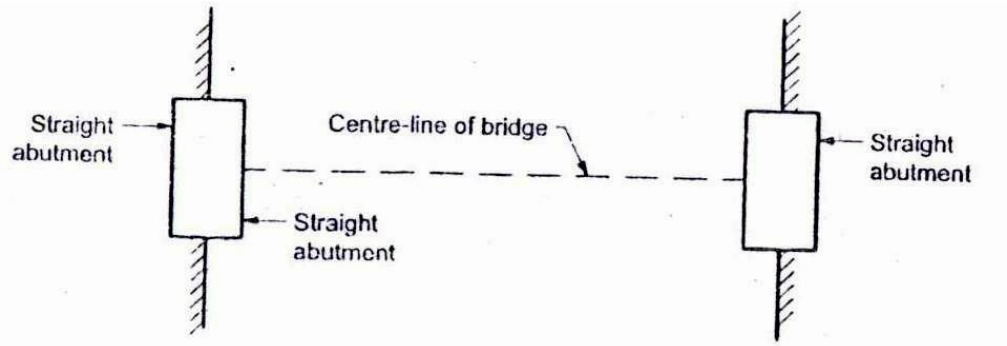


Fig. 3.9.1 : Straight abutment

(b) Tee abutment:

- The abutment of the "T" shape in plan are known as Tee abutment.
- This type of abutment provides more stability than straight abutment because of its projected leg.

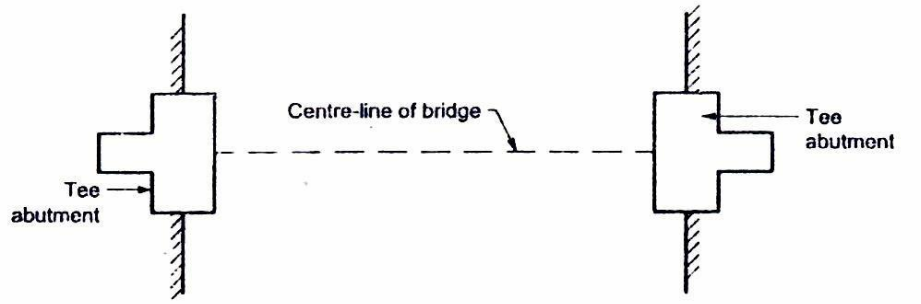


Fig. 3.9.2 : Tee abutment

(c) Hollow or arch abutment:

- The abutment curved in plan is known as Hollow or arch abutment.
- This types abutment are suitable in case of under bridge or grade separation.

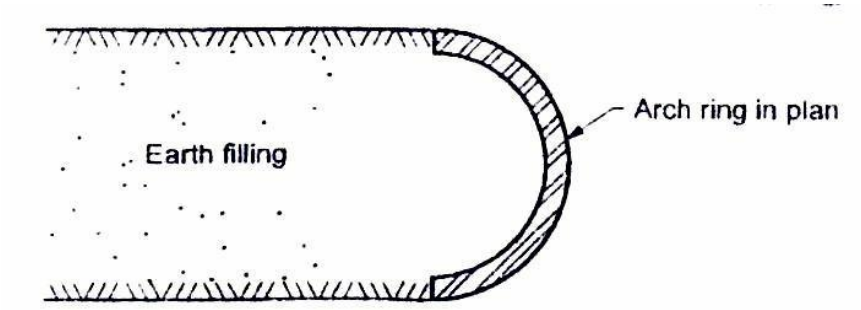


Fig. 3.9.3 : Hollow or arched abutment

2. Abutments with wing walls:

- These abutments are suitable in when:
  (a) Height of approach embankment is more.
  (b) Velocity of flow of river is high.
  (c) There is a danger of side erosion.
- **Types:**
  When the abutment is with wing walls, they may be of following types:
  a) Abutment with straight wing wall.
  b) Abutment with splayed wing wall.
  c) Abutment with return wing wall.

(a) Abutment with straight wing wall:

- When the wing wall is in line abutment, such abutment is called abutment with straight wing wall.
- These types of abutment are suitable for under bridge or grade separation.

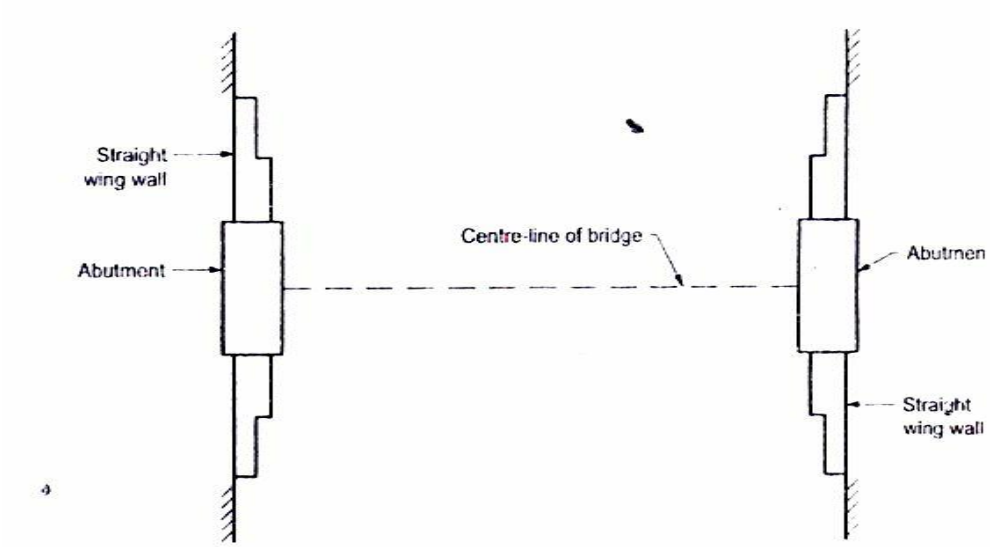


Fig. 3.9.4 : Abutment with straight wing wall

(b) Abutment with splayed wing walls:

- The abutment provided with splayed wing walls are known as abutment with splayed wing walls.
- Such abutments is very common for the bridge with waterway as it permits smooth entry and exit of water under the bridge.

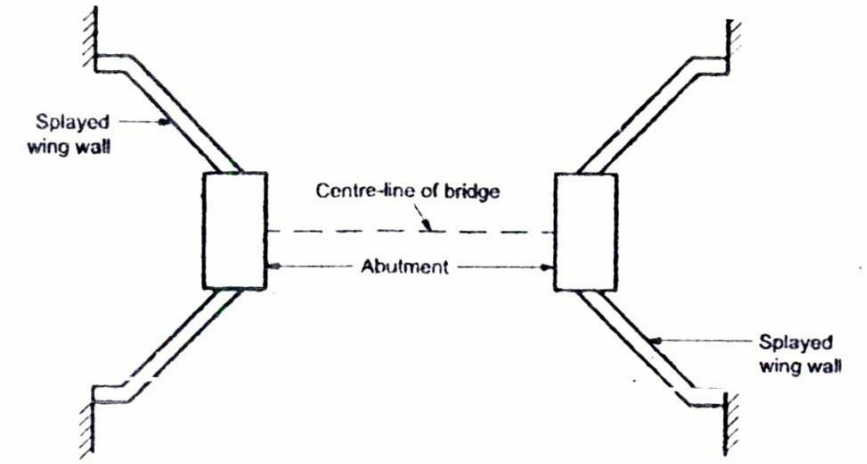


Fig. 3.9.5 : Abutment with splayed wing wall

(c) Abutment with return wing walls:

- The abutment provided with return wing walls are known as abutment with return wing walls.
- These abutment are suitable when:
  a) The height of the embankment is more.
  b) There is danger of side erosion.

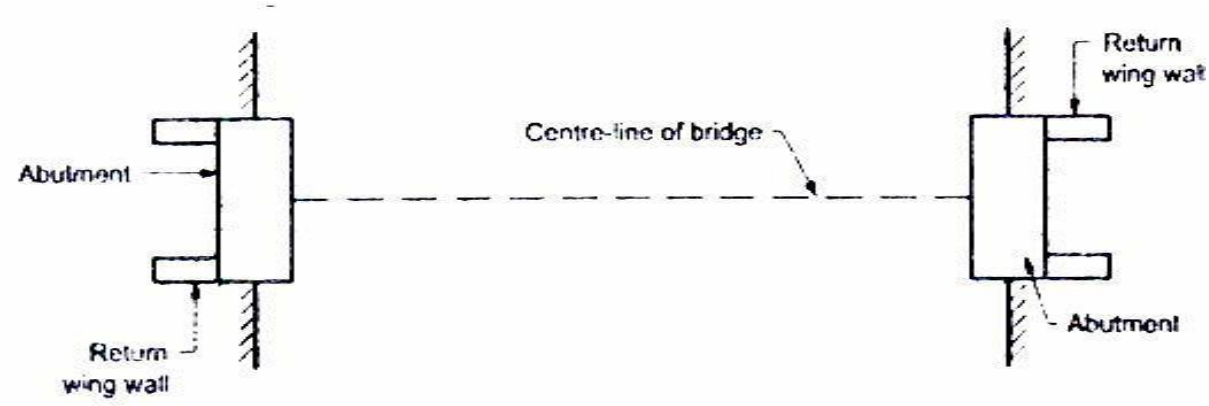


Fig. 3.9.6 : Abutment with return wing wall

Definition:

The intermediate supports of a bridge superstructure are known as piers.

Function:

1. To transmit the load form the bridge superstructure to the sub soil lying underneath

2. To divide the total length of bridge into suitable spans with minimum obstruction of the river.

- **Types:** Following are usual types of bridge piers:

Bridge piers

1. Soil piers	2. Open piers
(a) Solid masonry piers	(a) Cylindrical pier
(b) Solid R.C.C. piers	(b) Column bents
	(c) Pile bents
	(d) Trestle piers

(1) Solid piers:

- The piers which have a solid section in elevation, plan and end views are known as solid piers.
- Solid piers are suitable in water subjected to ice or debris.
- Solid piers may be of following type:

(a) Solid masonry pier
(b) Solid R.C.C. piers

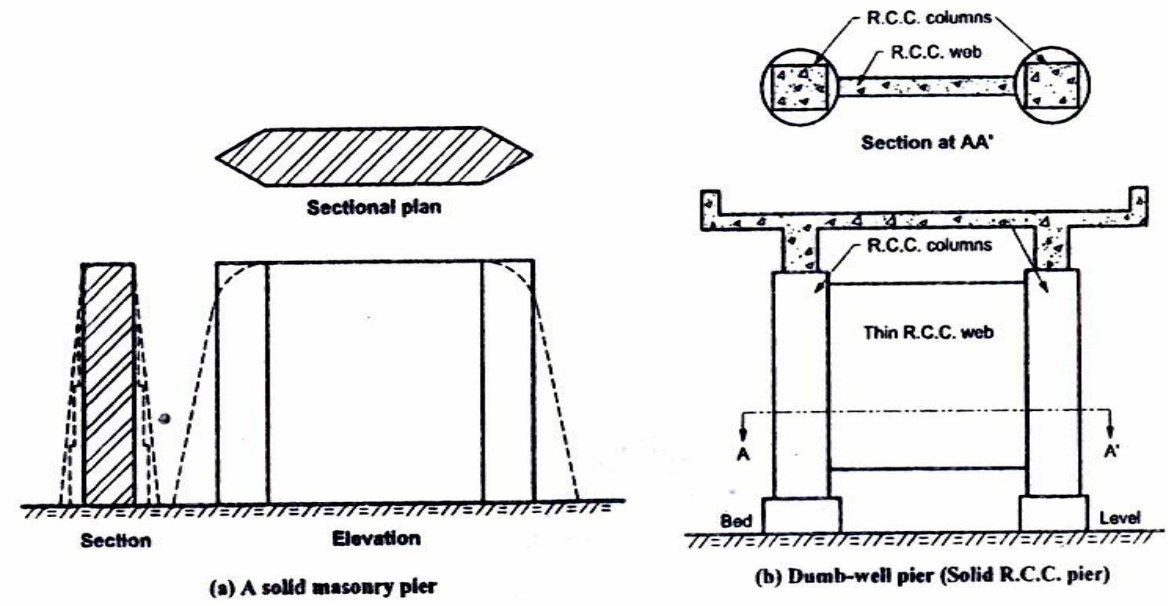


Fig. 3.9.7

Open pier:

The pier which do not have a solid section throughout their length and allow free passage of water through their structure are known as piers.

- Open piers may be of following types:
  (a) Cylindrical pier
  (b) Column bents
  (c) Pile bents
  (d) Trestle piers

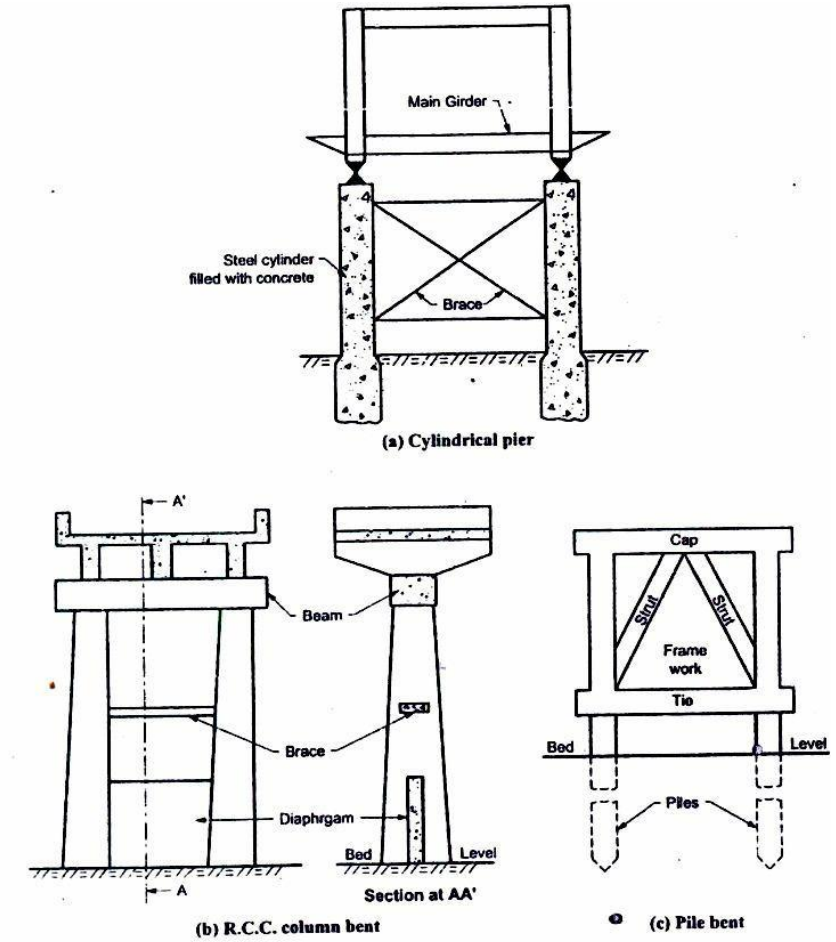
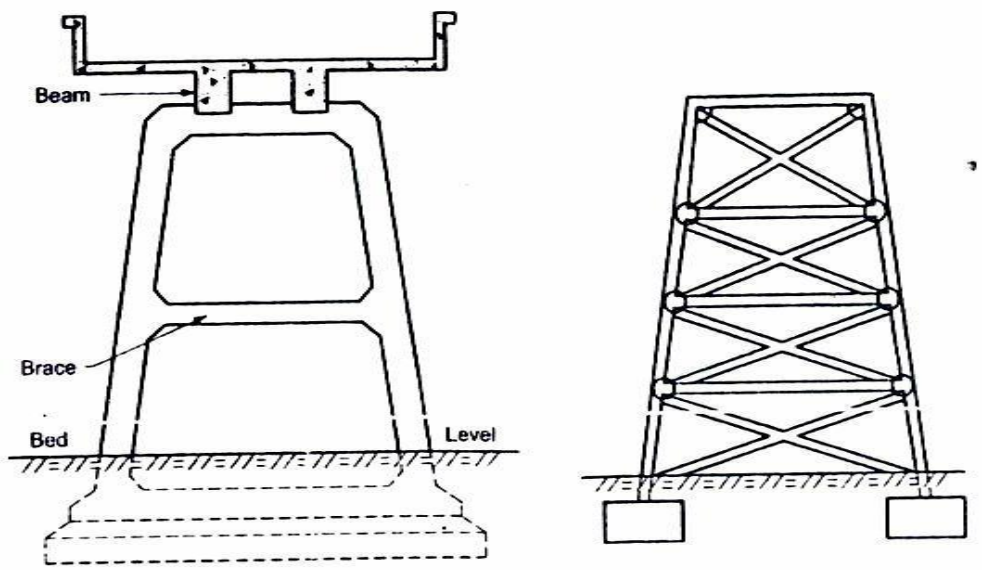


Fig. 3.9.8 Contd...



(d) Trestle bents

Fig. 3.9.8

III. Wing Wall:

- **Definition:**
  The walls constructed on either side of an abutment to support and protect the embankment are known as wing walls.

- **Function:**
  (1) To protect earth banks from the action of water
  (2) To provide a smooth entry into bridge site
  (3) To support and protect embankment

- **Types:**
  Following are the types of wing walls:
  (a) Straight wing walls
  (b) Splayed wing walls
  (c) Return wing walls

(a) Straight wing walls:

- The wing walls constructed in line with the abutment they are known as straight wing wall.
- Such walls are suitable for small bridge and culverts which are constructed across the drains having low banks.

(b) Splayed wing walls:

- The wing walls constructed at an acute angle with the abutment at both of their ends are known as splayed wing walls.
- The splay or inclination of wing wall is usually 45^{0}.
- Such walls are suited for small as well as big bridge on rivers.

- The splayed wing walls are best suited when the width of road is to be reduced while crossing the bridge.

(c) Return wing walls:

- When angle of wall becomes 90^0 the wing walls are known as the return wing walls.
- These types of wing walls are suitable in case when the embankments of approaches are very high.

IV. Approaches:

- **Definition:**
  The length of communication route affected by the layout and design of the bridge, at both of its ends are known as approaches.

- **Function:**
  (1) Function of approaches is to carry the communication route to the level of bridge floor.
  (2) To enable the vehicles running on a road railway track.

Types:

Bridges approaches are of following types:

(a) Approaches with straight abutment
(b) Approaches with abutments and retaining wall
(c) Approaches running over extended portion of the main bridge

(a) Approaches with straight abutments:

Where the height of the approach embankment is small such types of approaches are suitable.

(b) Approaches with abutment and retaining wall:

In urban areas where the land is costly such types of approaches are suitable.

(c) Approaches running over extended portion on the main bridge:

Such types of approaches are suitable under following situations:

(1) When it is not economical to cover the total span of the bridge, particularly in case of an arch or suspension bridge.
(2) When the bridge is extended into the bank for some distance to provide better substructure to the approaches and to protect them.

3.9.3 Superstructures:

Definition:

The upper part of a bridge consisting of structural system in the form of beams, girders, arches suspension cables etc. carrying the communication route is called superstructure.

Function:

(1) It provides carriage way.
(2) It helps to serve the intended function with safety and convenience.

3.10 Bridge Bearing:

- **Definition:**

The devices fixed on abutments and piers for free expansion, contraction and deflection sofa the bridge superstructure are known as bridge bearings (Refer Fig. 3.7.1(c)).

- **Function:**
  1. To distribute the load received over large area.
  2. To allow for longitudinal expansion or contraction due to changes in the temperature.
  3. To allow for angular movement at support due to deflection of girders.
  4. To allow for vertical movement due to sinking of supports.
  5. To transfer horizontal forces occurring due to application of brakes to the vehicle etc.
  6. To keep the compressive stress within safe limits.

3.11 Types of bearings:

The various bearings, being used for steel girder bridges are broadly classified into the following two categories:

3.11.1 Fixed Bearing:

- The bearings which do not permit any longitudinal movement of the bridge girders are known as fixed bearing.
- Usually angular movement or deflections of girders are allowed by fixed bearing.

Types of fixed bearings:

Fixed bearings are further classified into the following type:

1. Shallow and fixed plate bearings
2. Deep cast base bearings
3. Rocker bearings
4. Knuckle bearings

1. Shallow or fixed plate bearings:

- This is simplest type of fixed bearings.
- It consists of flat rectangular steel plate attached to the lower flange of te bridge girder.
- Two anchor bolts are used to the anchored down the steel plate one on each side of the girder on the top of bridge pier or abutment as shown in Fig. 3.11.1.
- It is suitable upto 12m span of steel girder bridge.

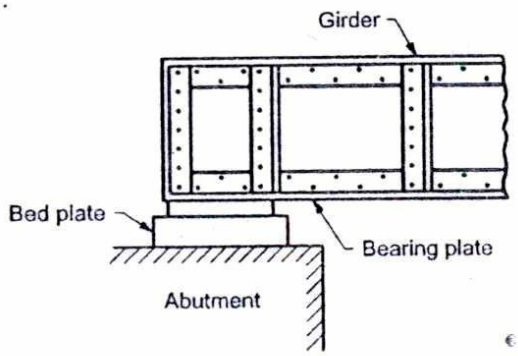


Fig. 3.11.1 : Shallow or fixed plate bearing

2. Deep-cast base bearings:

- In this case deep cast base is attached to the under side of the bridge girder as shown in Fig. 3.11.2.
- This type of bearings avoids the concentration of reaction at the inner edge of bearing.
- Thus distributes the load over abutments.
- It is suitable for span of 12 to 20 m span of steel girders bridge.

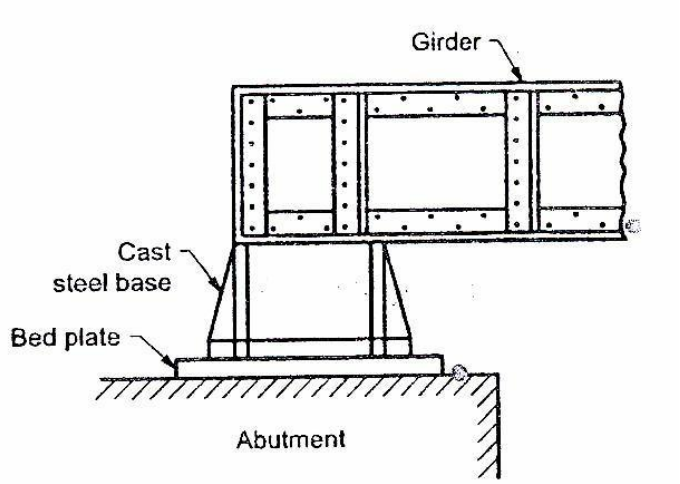


Fig. 3.11.2 : Deep cast base bearing

3. Rocker bearings:

- A fixed bearing which rocks about pin like hinge is known as a rocker bearing.
- Rocker pin is provider between the top and bottom shoe.

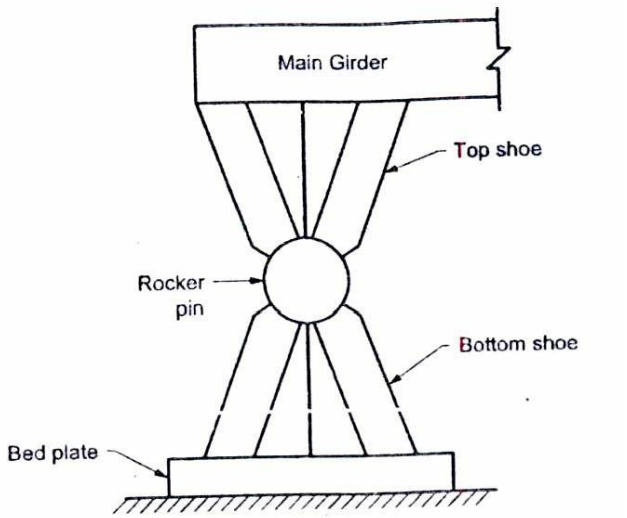


Fig. 3.11.3 : Roker bearing

- This bearing allows only free angular movement of the main girder. Also, it transmits the pressure centrally to the bed plate.
- This type of bearing is suitable for long spans (cover 20m) of girder bridges.

4. Knuckle bearings:

- In this type of bearing the top of bottom shoe and the bottom of top shoe are given semi circular shapes as shown in Fig. 3.8.4.
- The knuckle bearing is adopted when it is desired to provide only for angular movement of the girder which is fixed to the top shoe.
- This type of bearing is suitable for long spans (cover 20m) of grider bridges.

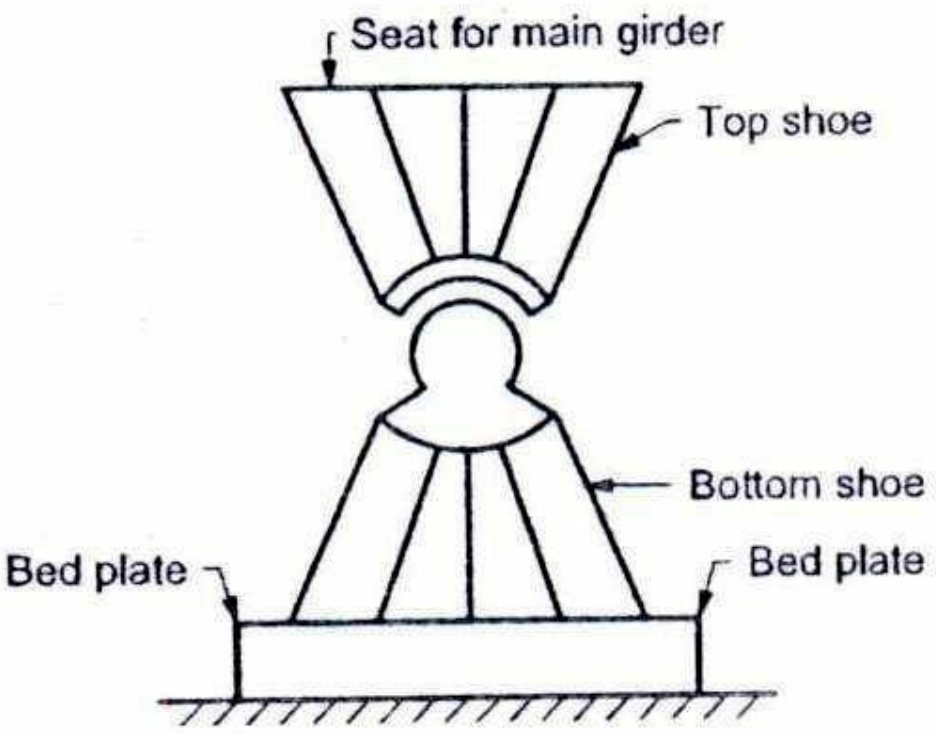


Fig. 3.11.4 : Knuckle bearing

3.11.2 Expansion Bearings:

- The bearings which allow longitudinal movement of the bridge girders are known as expansion or free bearing.
- **Types of expansion bearings:**
  Expansion bearings are further classified into the following types:
  1. Sliding plate bearings
  2. Deep cast base curved plate bearings
  3. Rocker bearing with curved base
  4. Rocker and roller bearings

(1) Sliding plate bearings:

- The is the simplest type of expansion bearing.
- It consists of sole plate which is provided between main girder and bed plate as shown in Fig. 3.11.5.
- The bed plate is fixed rigidly to abutment by anchor bolts.
- The sole plate is attached to the bed plate by bolts through the slotted holes of the sole plate.
- The sliding bearing allows only longitudinal movement of main girder.

- This type of bearing is also suitable for span 12 to 20m.

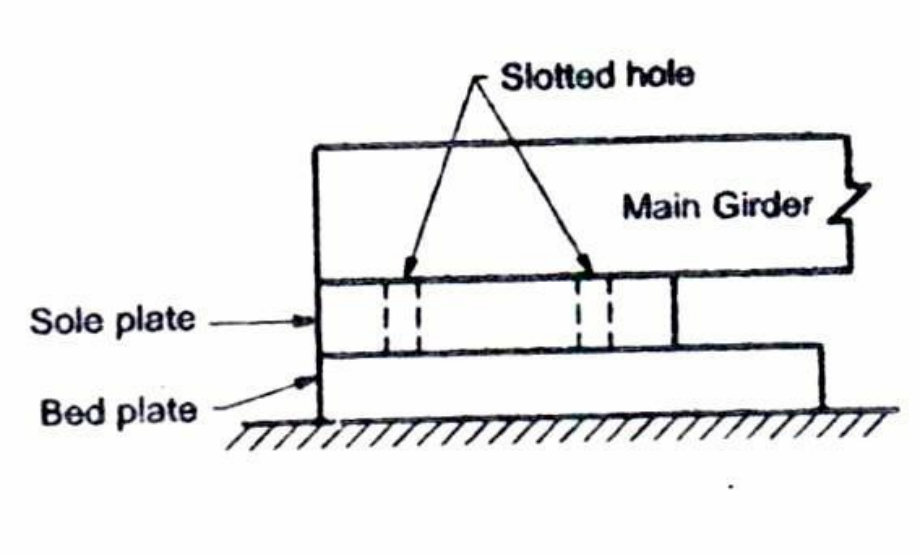


Fig. 3.11.5: Sliding bearing

(2) Deep cast base curved plate bearings:

- This type of bearing consists of a sole plate which is fixed to the underside of the main girder.
- Sole plate rests on a deep case base with curve bed plate.
- Curve bed plate fixed to abutment.
- This type of bearing is useful to allow free angular movement of the main girder.
- This type of bearing is suitable for span 12 to 20m.

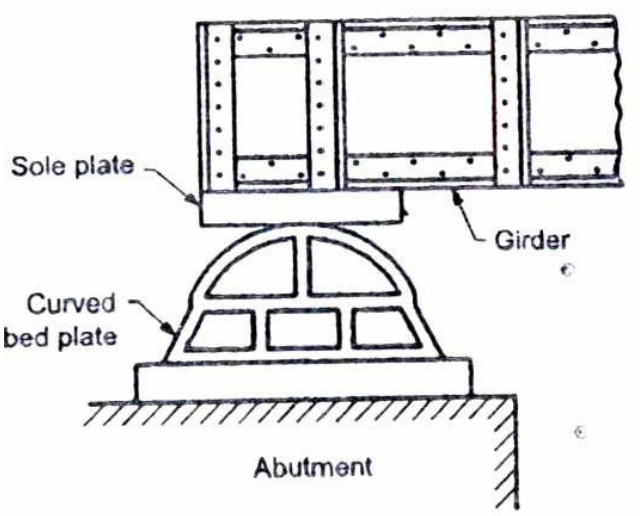


Fig. 3.11.6 : Deep cast base with curved

(3) Rocker bearing with curved base:

- This is a type of Rocker bearing.
  In this type of bearing the bottom shoe is given a circular shape.
- The top shoe is provided with drill holes for fixing of the girder.
  This type of bearing allows for the deflection and expansion of the bridge
- girder with a reduced horizontal force.

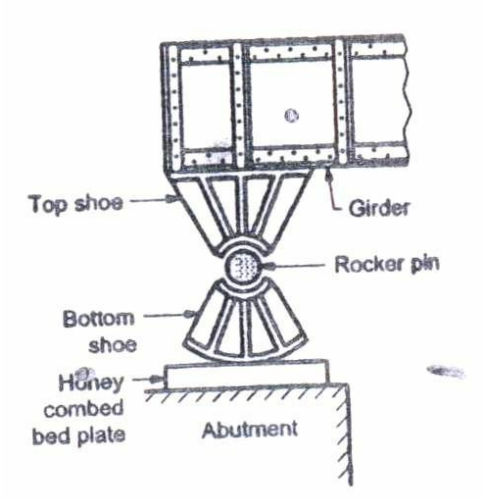


Fig. 3.11.7: Rocker bearing with curved bottom base

(4) Rocker and roller bearings:

- This type of bearing consists of a rocker pin which is provided between the top shoe and the bottom shoe.
- Bottom shoe rest on number of steel rollers as shown in Fig. 3.11.8.
- Steel rollers rest on bed plate which is attached to top of abutment.
- This type of bearing allows for free longitudinal as well as angular movements of the bridge girder.
- This type of bearing is suitable for spans more than 20m.

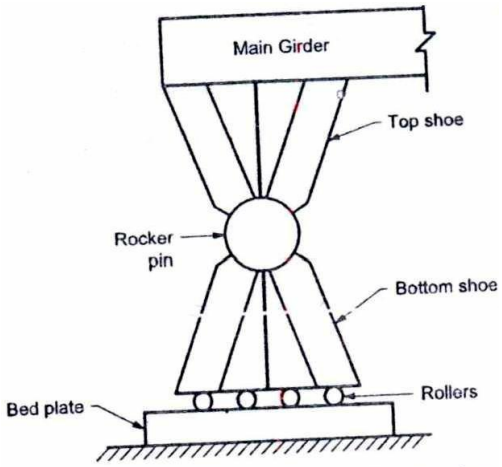


Fig. 3.11.8 : Rocker and roller bearing

3.12 Type of Bearing for R.C.C. Bridge:

The bearing used for concrete bridges are classified as:

I. Bearing for slab bridges
II. Bearing for girder bridges
III. Bearing for submersible bridge
IV. Bearing for continuous bridge

(I) Bearing for slab bridges:

- The bearing simply consists of several layer of tar paper, placed between the bridge slab and capping slab of the pier or abutment.
- In order to prevent bonding of concrete layers of tar paper are provided.
- Such type of bearing is used in case of slab bridges upto 8m span.

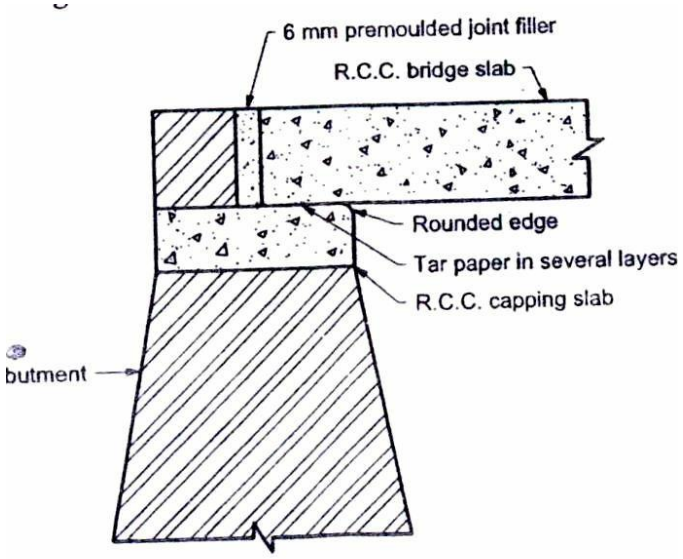


Fig. 3.12.1: Bearing for a slab bridge

- **Bearing for the slab bridges are of following types:**
  (a) Fixed end bearing
  (b) Free end bearing

(a) Fixed end bearing:

The bearings which do not provide free expansion of the bridge slab but may allow its rotating movement is known as fixed end bearing.

(b) Free end bearing:

The bear which provide free expansion of the bridge slab are known as free end bearings.

(II) Bearing for girder bridges:

- These bearing consist of a lead sheet which is placed between two mild steel plates.
- The base plate is attached to the abutment or pier and the top plate is attached to the girder.
- This bearing is suitable for span of 8 to 27 m.
- Bearing for the girder bridges are of the following types:
  (i) Fixed plate bearing
  (ii) Sliding plate bearing
  (iii) Sliding plate bearing with curved top plate
  (iv) Free bearings

(III) Bearings for submersible bridges:

- For small submersible bridges ordinarily two plate sliding bearings at the free end and two plate bearing at fixed end, with or without curvature in the top plate for rocking are provided.
- The material of the plate should be copper alloy or stainless steel which does not rust.

(IV) Bearing for continuous span bridges:

- When the total length of continuous span is less than 14m, no bearing is required.
- In such case, several layers of tar paper may be provided between the abutment or pier and super structure.

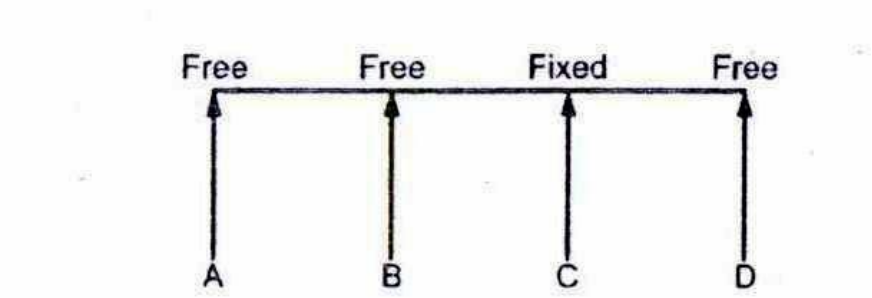


Fig. 3.12.2 : Bearing for continuous span bridges

- When the total length is more than 14 m, bearings are provided. Maximum length affected by temperature
- In this case fixed bearings are provided at one of its intermediate support.

3.13 Bridge Flooring:

The top surface of bridge is covered up with suitable flooring material.

3.13.1 Factors Affecting the Choice of flooring material:

1. Availability of local labour and material.
2. Nature and importance of bridge
3. Intensity and nature of traffic.
4. Funds available.
5. Use of bridge.

3.13.2 Types of Floors:

The bridge floors are of following two types:

1. Open floors
2. Solid floors

1. Open floors:

- The space between main girders is covered by the require parts of floor and remaining is kept open, where no flooring material is required such floors are known as open floor.
- These types of floors are usually used in case of the railway bridge.
- The open floors will not require any drainage provisions.

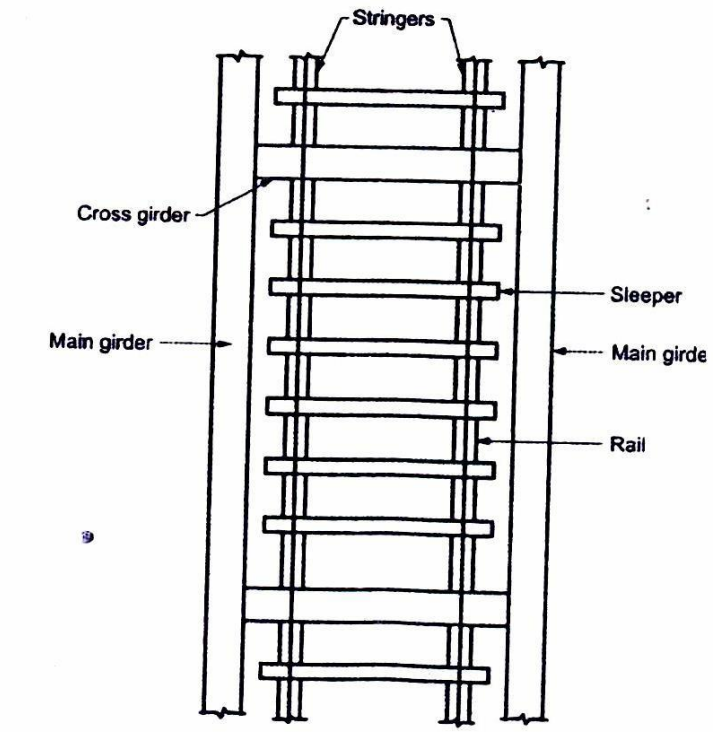


Fig. 3.13.1 : Open floor

2. Solid floors:

- When the top surface of the floor of bridge is covered up by a suitable flooring material, then such floors are known as solid floors.
- Flooring materials:
  Following flooring materials are generally used for the solid floors:

i. Timber
ii. Reinforced cement concrete
iii. Mild steel troughs
iv. Mild steel plates
v. Mild steel buckle plates
vi. Jack arch

(i) Timber:

- For such flooring, the wooden planks of suitable thickness are used.
- These floors are light in weight.
- Such floors are suitable for light traffic for example foot-overs.
- However, they are liable to catch fire.

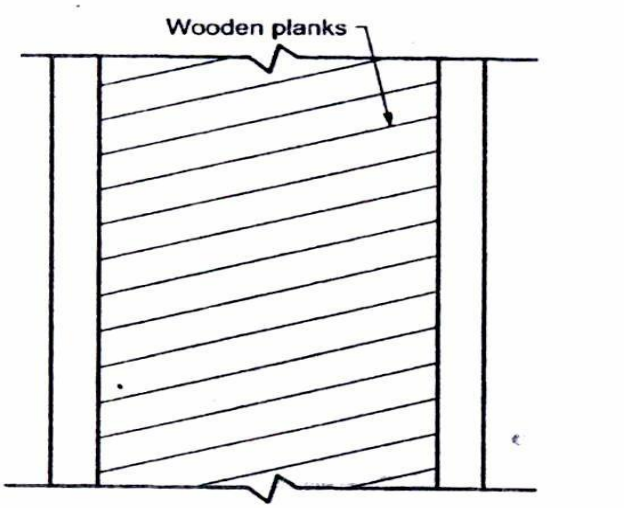


Fig. 3.13.2 : Timber floor

(II) Reinforced cement concrete:

- Such type of floor consists of slab of suitable thickness with necessar y reinforcement.
- Such type of floors is widely used in case of Highway Bridge.

(iii) Mild steel troughs:

- A trough is a steel section prepared in a shape as shown in Fig. 3.13.3
- The troughs are filled with concrete with a depth of about 75 mm above the top of trough.
- A bituminous layer is provided over the concrete.

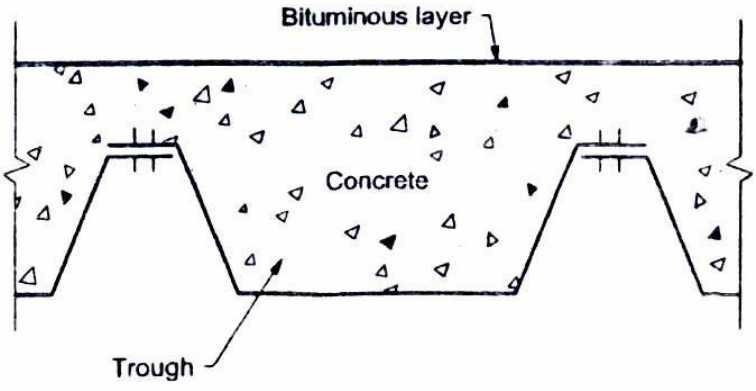


Fig. 3.13.3 : Trough floor

(IV) Mild steel plate:

- The flat mild steel plates of thickness about 15mm are provided as flooring material for the bridge.

- Plates are provided with enough holes to drain off the rain water.

(v) Mild steel buckle plates:

- The mild steel buckle plates are bent in form of an arch.]
- Thickness of plate varies from 6 mm to 11mm.
- The space above the buckle plates is filled up by concrete or asphalt to a depth 75 mm above the crown.

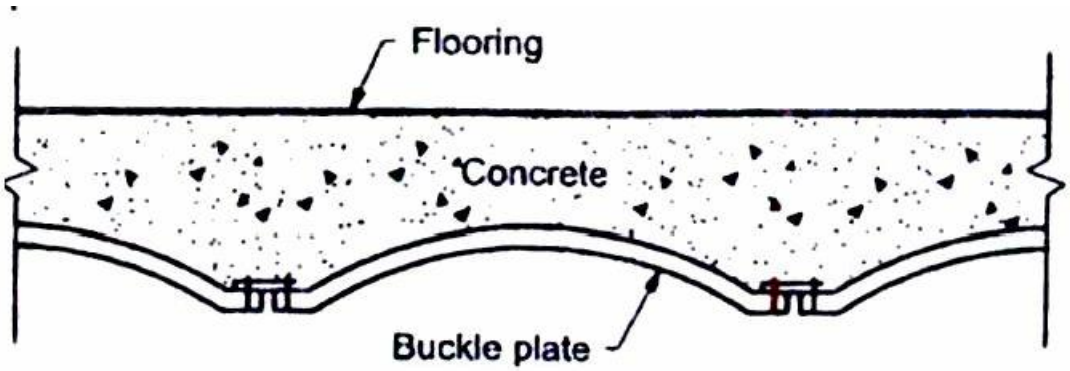


Fig. 3.13.4 : Buckle plate floor

(vi) Jack arch:

- In this type of floor, arches of cement concrete are constructed as shown in Fig. 3.13.5
- These arches rest on the mild steel joist.
- The joist in turn rests on R.S. beam.
- A suitable elastic material is provided at the top of arches to absorb the shocks due to impact.

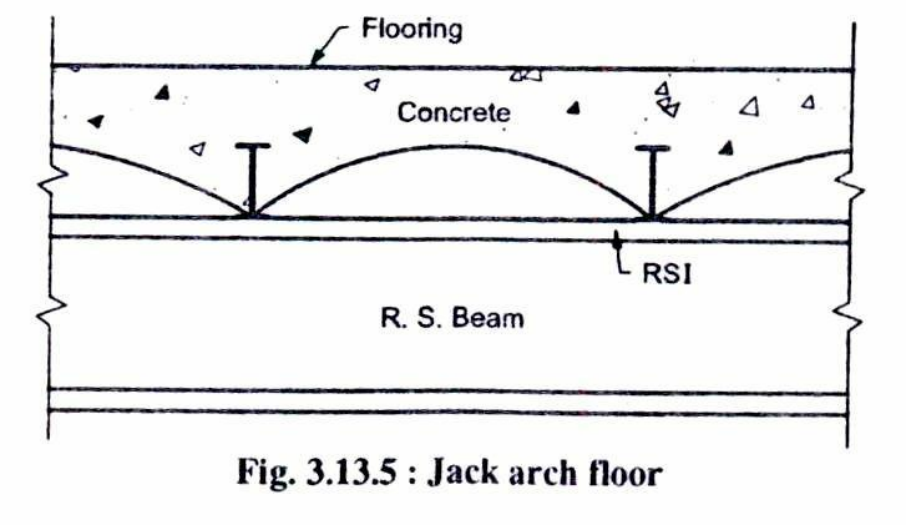


Fig. 3.13.5 : Jack arch floor

3.14 Permanent Bridge:

Definition:

The bridge constructed as well as maintained at high cost and have long span of useful life are known as permanent bridge.

3.14.1 Culverts:

- **Definition:**
  A culvert is defined as a small bridge constructed over a stream which remains dry for most part of the year.

- **Types of culverts:**
  Culverts are classified into following type:
  1. Arch culvert
  2. Box culvert
  3. Slab culvert
  4. Pipe culvert

  1. Arch culvert:

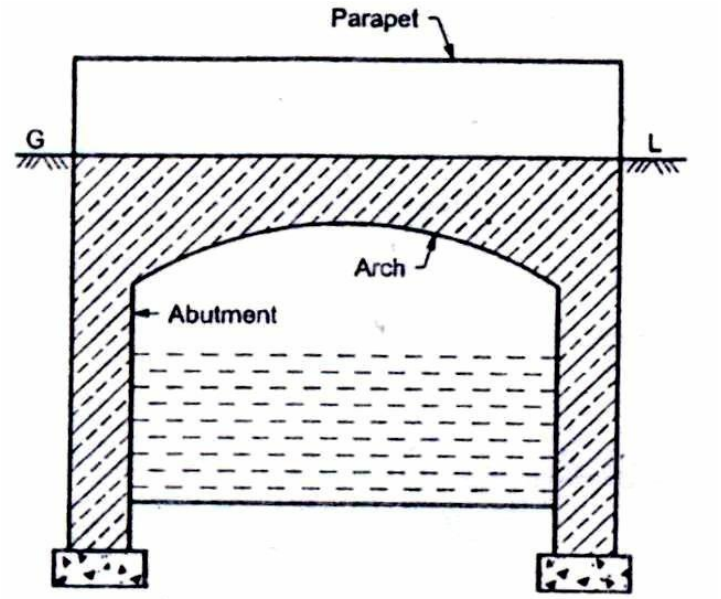


Fig. 3.14.1 : Arch culvert

- The culvert having its superstructure consisting of single or number of arches constructed of any suitable masonry is known as arch culvert.
- The arch culvert is provided with the abutments, wing walls and parapet.
- An arch culvert of masonry may be adopted for span ranges of 2 m to 6m.
- Arch culverts are especially suitable where the approaches are to be constructed in cuttings.

2. Box culvert:

- In case of box culvert rectangular or square boxes are formed of masonry, R.C.C
- Box have their floor and top slabs constructed monolithically with abutment and piers
- Box culvert is provided one or more number of units with individual spans ranging from 1 m to 4m.
- This type of culvert can be conveniently used for a single span of 3m or for a double span of 6 m.
- Box culverts are specially suitable when soil is soft and the load has to be distributed over wider foundation area.

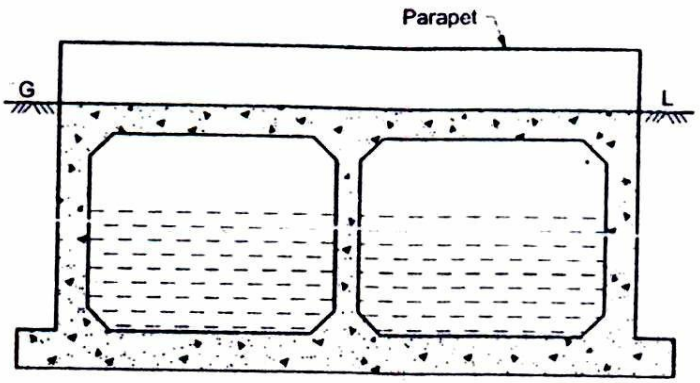


Fig. 3.14.2 : An R. C. C. box culvert

3. Slab culvert:

- A slab culvert consists of stone slabs or R.C.C. slabs supported on masonry wall as shown in Fig. 3.14.3

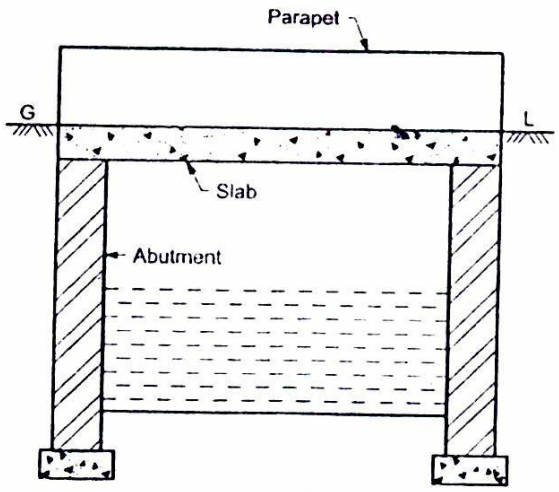


Fig. 3.14.3 : Slab culvert

- These culverts are constructed up to the span of 3m or so.
  The construction of slab culvert is relatively very simple.
- This type of culvert can be used for highway, railway and bridges.
  Slab culvert are suitable where the bed of stream or canal is sufficiently firm.

(4) Pipe culvert:

- For small stream crossing the road or railway embankments one or more pipes may be laid to act as the culvert is known as pipe culvert.
- The diameter of pipe is always more than 300 mm.
  Such type of culvert consists of cast Iron, steel or R.C.C. pipes held in position over concrete base.

- The exact number of pipes and their diameters will depend on the discharge an height of bank.
- Pipe culverts are suitable where the flow of water in the stream is very less and when discharge is low say upto 10m /sec.

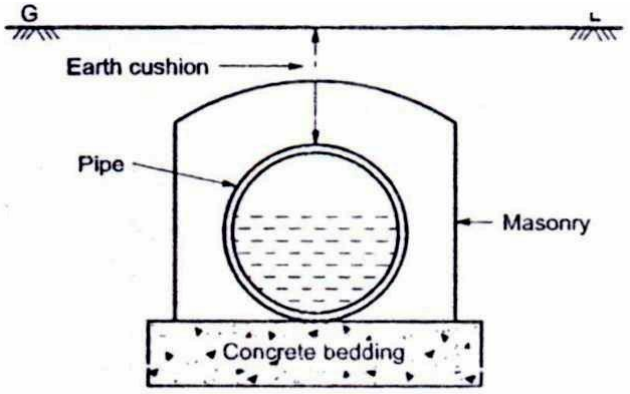


Fig. 3.14.4 : Pipe culvert

3.14.2 Causeways:

- **Definition:**

A causeway is defined as a small submersible bridge at or about the bed level which will allow the floods to pass over it. It is also known as Irish causeways.

- Causeway may be provided under the following conditions:

(1) The seasonal flow is less.
(2) When the depth of water in the stream is very low.
(3) In hilly areas, where a number of small streams cross the road.
(4) Where sufficient funds are not available.

- **Types of cause ways:**

Causeways are classified into the following types:

1. Flush causeways
2. Low level causeways
3. High level causeways

1. Flush causeways:

- The causeway having their floor flush with the bed of the stream without any vent is know as flush causeways.

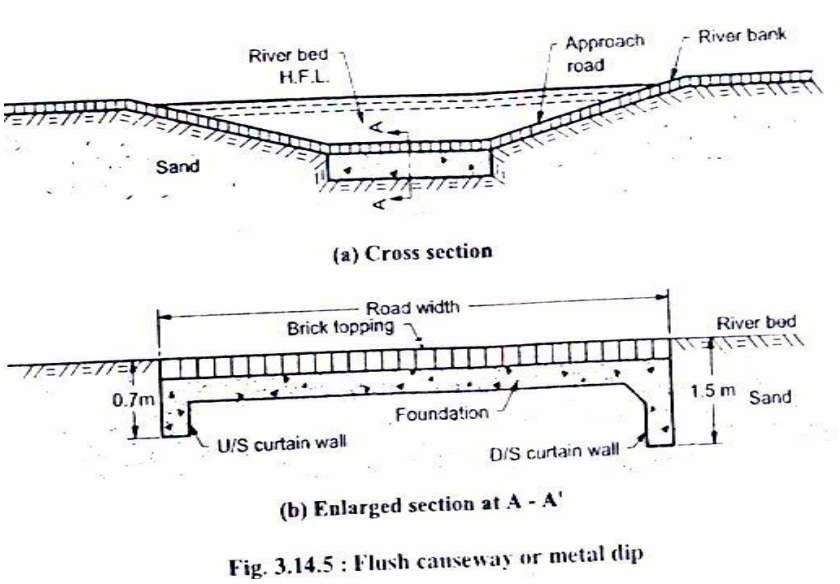


Fig. 3.14.5 : Flush causeway or metal dip

- Types type of causeway is usually provided in hill roads for shallow non-perennial streams where maximum depth of water in floods is less than 1.75m.
- Where flood water runs only for short period (10 to15 days in a year).
- Such type of causeway consists of R.C.C. slab provided in the bed for smooth surface.

2. Low level causeways:

- The causeways having one or more vent provided under the roadway slab for passing the small discharge through them during dry season are known as low level causeway.

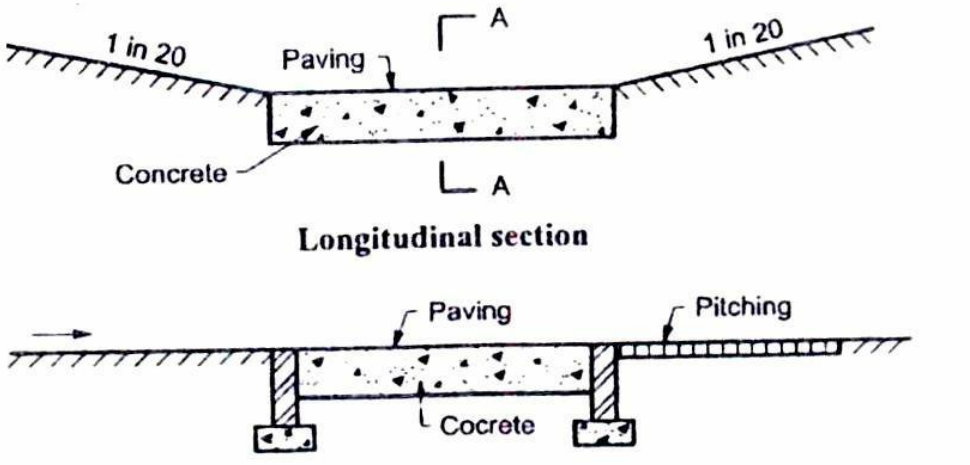


Fig. 3.14.6 : Low level causeway

- This type of causeway is suitable for shallow perennial rivers, where discharge is small for most of the year and where heavy discharge flows in rainy season for few hours.

3. High level causeways:

- A high level causeway is submersible road bridge designed to be overtopped in floods, it is also known as submersible bridge.
- High level causeway consists of sufficient number of openings, to allow the normal flood discharge to pass through them
- They are provided with abutment and piers, floors and slabs or arches to form required number of opening.
- High level causeway are suitable on river with small widths and straight reaches when the duration of high flood does not exceed 3 days in a year and for bus traffic on unimportant roads.

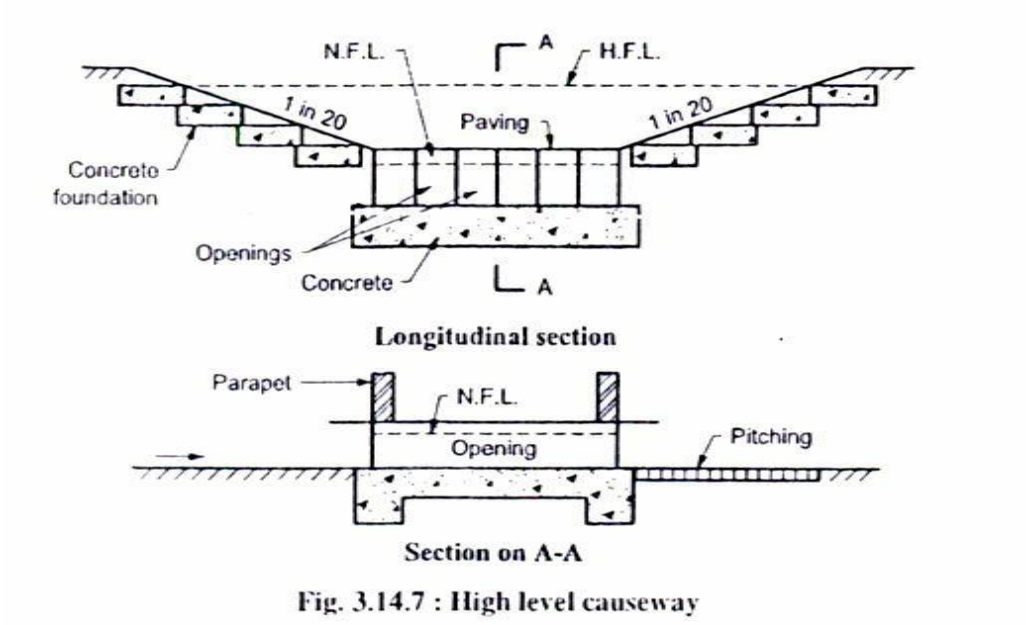


Fig. 3.14.7 : High level causeway

3.14.3 Arch Bridges:

- **Definition:**
The permanent bridge having their superstructure consisting of a number of arches, resting with their ends on piers and abutments are known as arch bridges. The rise of the arch is kept as large as possible so as to reduce the horizontal thrust and to economise on the design of the piers, abutments and foundations.

- **Types of arch bridges:**
The arch bridges are classified into following types:
(1) According to condition of spandrel
(2) According to number of hinges
(3) According to shape
(4) According to width

(1) According to condition of spandrel:

- Depending upon the condition of space above the arch and below the formation level, the arches are classified as:

(a) Filled spandrel (b) Open spandrel

(a) Filled spandrel:

- If the side walls are taken upto the bottom of formation level and the interior portion is filled up either by earth or any other suitable material upto the road formation level then it is known as filled spandrel arch.

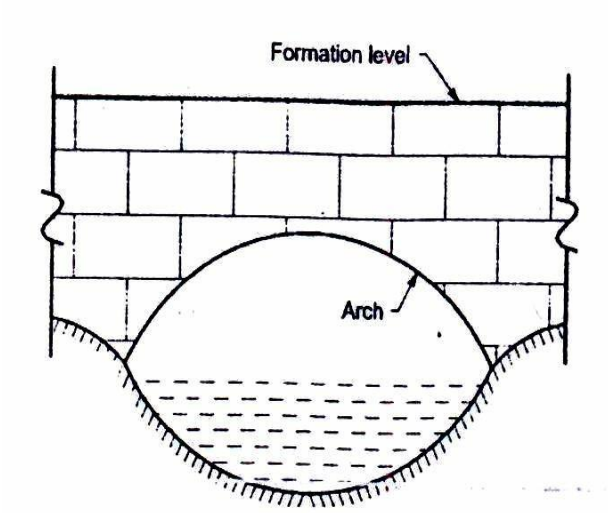


Fig. 3.14.8 : Filled spandrel arch

- Such types of arches are suitable when ratio of rise to span is small.

(b) Open spandrel:

- The flooring of bridge is supported by beams and columns or by arch and column and the space between column is kept open such arch is known as open spandrel arch.

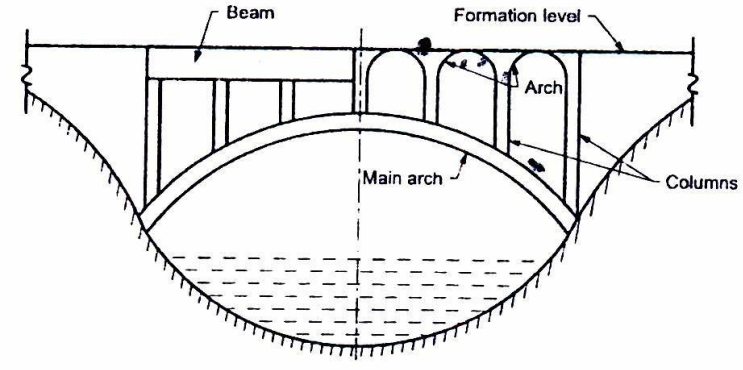


Fig. 3.14.9 : open spandrel arch

- This type of arch is aesthetically good.
- Open spandrel arch is suitable when ration of rise to span is high.

(2) According to number of hinges:

- Depending upon the number of hinge provided, the arches are classified as:
  (a) Hingeless or fixed arch
  (b) One hinge arch
  (c) Two hinge arch
  (d) Three hinge arch

(a) Hingeless or fixed arch:

- Arch which does not contain any hinge is called hingeless or fixed arch.
- Such types of arches are suitable where hard unyielding soil is available for the support of an arch.

(b) One hinge arch:

- Arch which contains only one hinge at crown is called as one hinge arch as shown in Fig. 3.14.11.

(c) Two hinge arch:

- When arch contains two hinge at the supports i.e. pier or abutment then such arch is known as two hinge arch.
- The two hinge arch are simple for analysis.
- They are easily adaptable for the construction of concrete and steel arches.

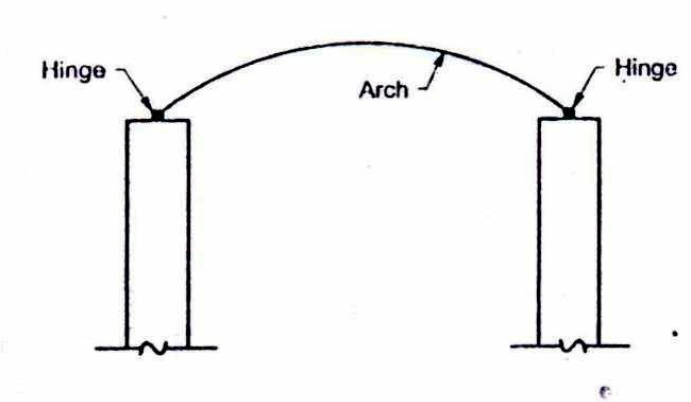


Fig. 3.14.12 : Two-hinged arch

(d) Three hinge arch:

- When arch containg three hinges one at crown and other at springing points, then such arch is known as three hinged arch.
- This arch is structurally stable.
- It is used when it is difficult to obtain hard soil at reasonable depth.

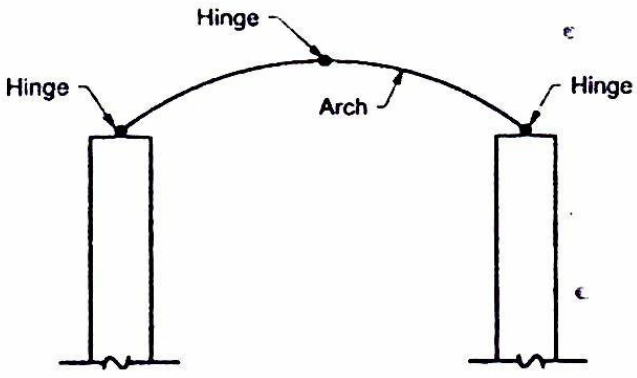


Fig. 3.14.13 : Three-hinged arch

(3) According to shape:

- The arch bridge can also be classified according to the shape of arch.
- The commonly used shapes of bridge arches are semi-circular, segmental pointed semi-elliptial etc.

(4) According to width:

Depending upon the width of the arch in transverse direction of bridge, the arches are classified as:

- **(a) Barell type**

(b) Rib type

3.14.4 Steel Bridges:

- **Definition:**
  The bridge having their superstructure consisting of steel member in any structural form are known as steel bridges.

- **Types of steel bridges:**
  Steel bridges are classified into following types:

1. Steel trough plate bridge
2. Steel girder bridge
3. Steel arch bridge
4. Steel truss bridge
5. Bow string girder bridge
6. Continuous steel bridge
7. Steel rigid frame bridge
8. Steel suspension bridges
9. Steel cantilever bridges

10. Steel movable bridges

(1) Steel trough plate bridge:

- **Definition:** The bridge having its superstructure consisting of only steel troughs which carry the bridge floor is known as steel plate bridge.

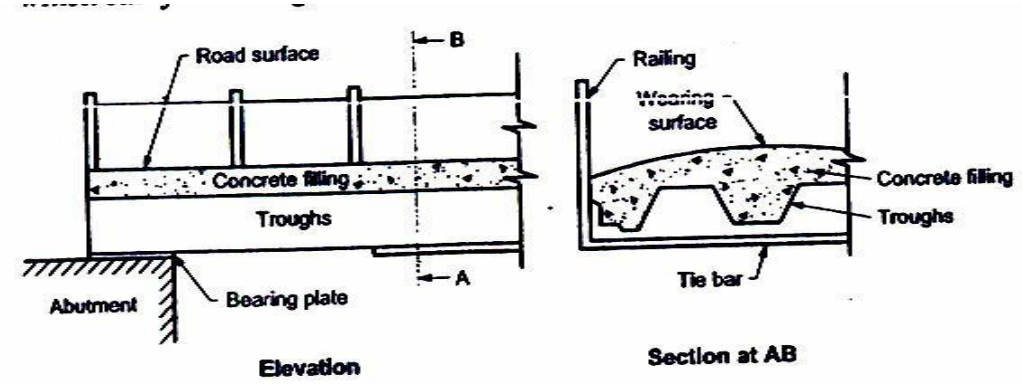


Fig. 3.14.16 : Steel trough plate bridge

- Such type of bridge is suitable for spans upto 1.5m.

(2) Steel Girder Bridge:

- **Definition :**The bridge having its superstructure consisting of steel girders which carry the bridge floor is called as steel girder bridge.

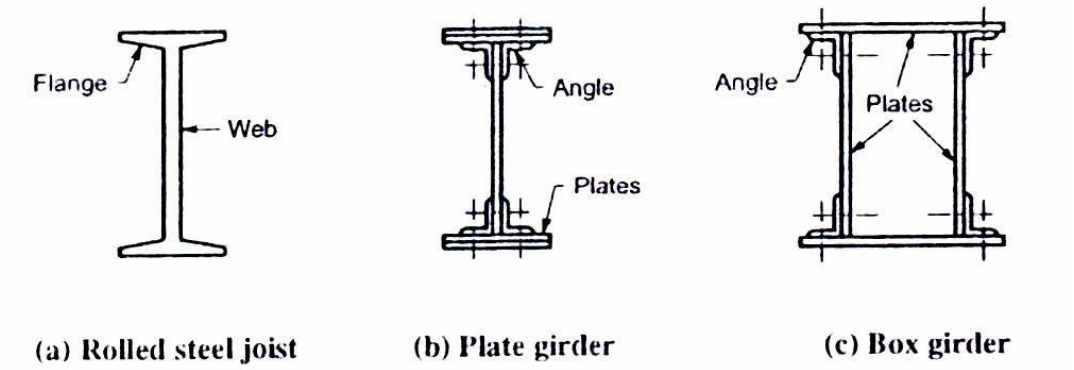
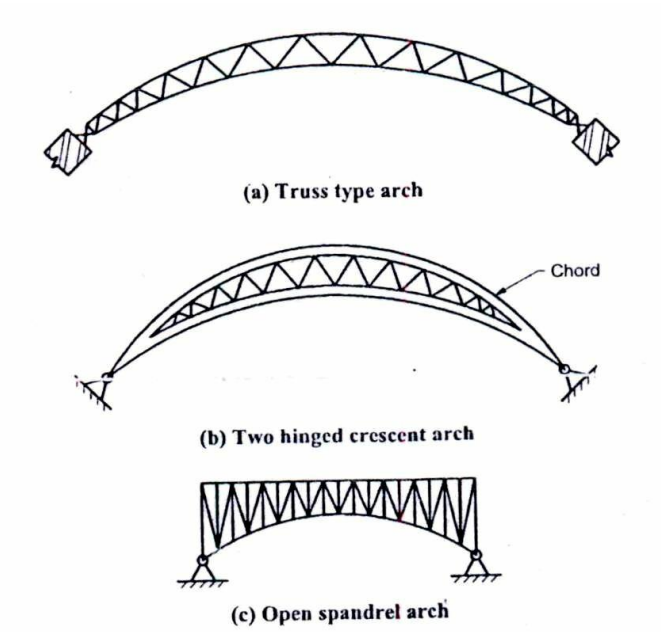


Fig. 3.14.17 : Types of steel girder

- This type is used mainly for small span railway bridge. The maximum span should be less than 15 m.

(3) Steel arch bridge:

- The bridge having its superstructure consisting of steel arch which carry the bridge floor is called steel arch bridge.



(a) Truss type arch

(b) Two hinged crescent arch

(c) Open spandrel arch

Fig. 3.14.18 : Various steel arches used for steel arch bridges

- Steel arch bridges are suitable where it is very difficult to construct intermediate piers due to poor bed conditions of stream and velocity of flow of the stream water is very high.

(4) Steel truss bridges:

- **Definition:** The bridge having its superstructure consisting of steel trusses which carry the bridge floor is called as steel truss bridge.

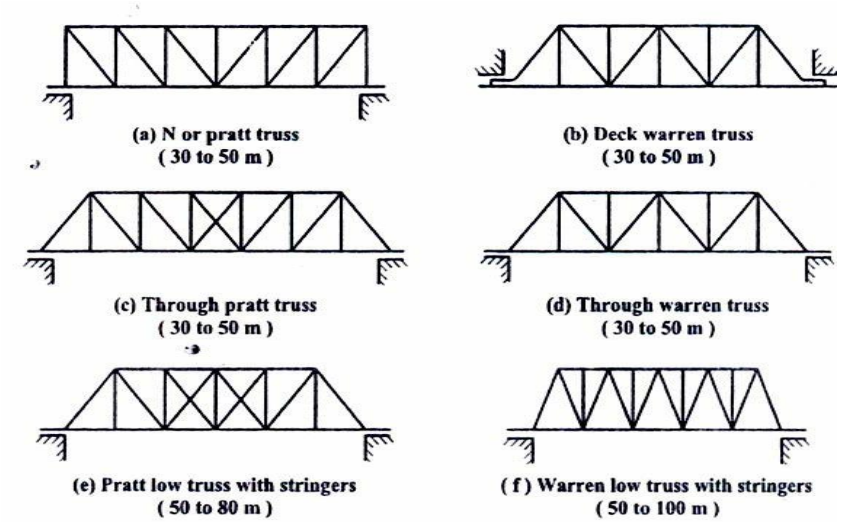


Fig ,3.14.19 : Contd....

- Steel truss bridges are commonly used for carrying heavy loads on long spans for road and railway bridges.
- These bridges are economical for span of greater then 30m.

(5) Bow string steel girder bridges:

- **Definition:** The bridge having its superstructure consisting of a set of steel bow string girders which carry the bridge floor on their ties is known as bow string steel girder bridge.

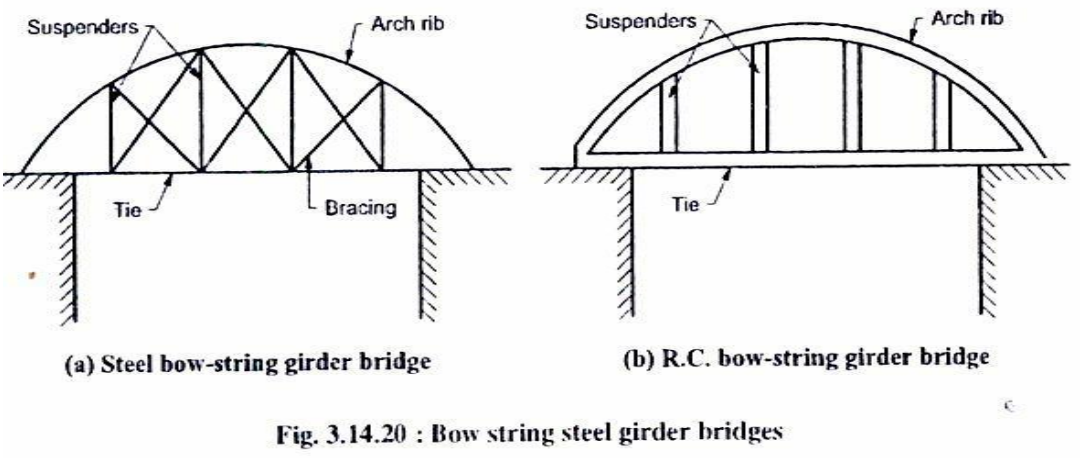


Fig. 3.14.20 : Bow string steel girder bridges

- Bow string steel girder bridges are suitable for very large spans upto 250 m.
- These bridges are now rarely used.

(6) Continuous steel bridges:

 Definition: The bridge having its superstructure consisting of a set of steel bow string girders which carry the bridge floor on their ties is known as bow string steel girder bridge.
 Bow string girder bridges are suitable for very large spans upto 250m.
 These bridges are now rarely used.

(6) Continuous steel bridges:

 Definition : The bridge having its superstructure consisting of a double track three span constinuous through type steel which supports the bridge floor is kanown as continuous steel bridges.

 Such types of bridges are more suitable for specific load conditions.

(7) Steel rigid frame bridges:

 Definition : The bridge having its superstructure as well as substructure which carry the bridge floor is known as steel rigid frame bridge.

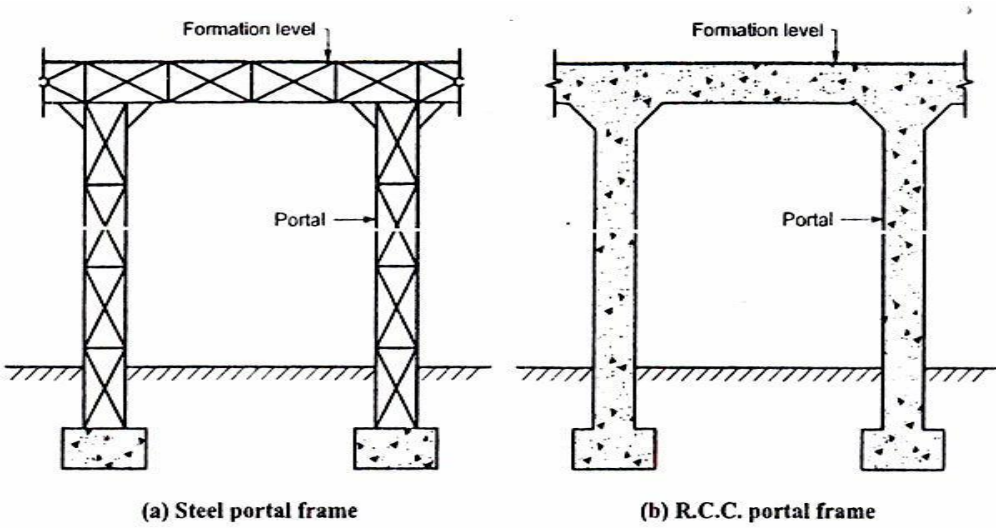


Fig. 3.14.21 : Steel rigid frame bridge

 Steel rigid frame bridges are well suited; where more clearance is required for the free passage of boats under the bridge superstructure and where the cost of excavation for abutment is high abutment is high.

(8) Steel suspension bridge:

 Definition: The Bridge having its superstructure consisting of one or two set of cables which carry the bridge floor by means of suspenders is known as steel suspension bridge.

 Cables are usually made of chain or steel wire ropes.

 The suspenders are usually of twisted wire ropes and are connected with the cable by loops.

 Types of steel suspension bridge:

1. Simple or unstiffened suspension bridge
2. Stiffened suspension bridge

(1) Simple suspension bridge:

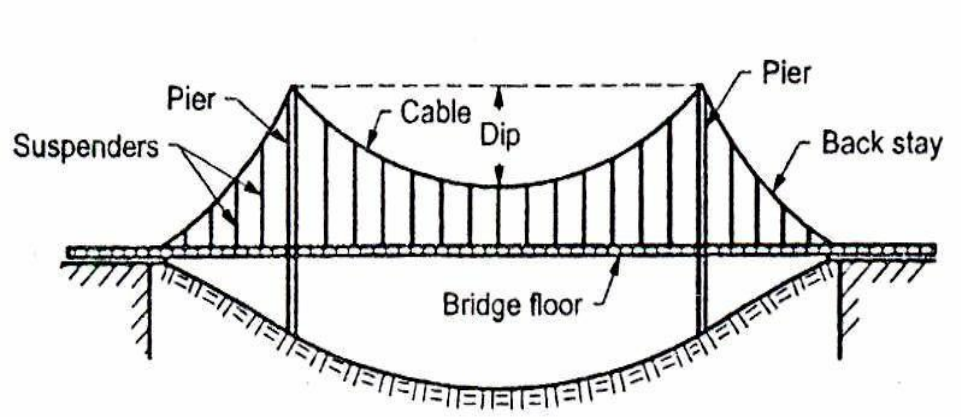


Fig. 3.14.22 : Simple suspension bridge

 No stiffening is required for suspension bridge with light loads such bridge is called simple suspension bridge.

 It can be adopted for light traffic and for Foot Bridge.

(2) Stiffened suspension bridge:

 When the stiffening trusses is provided at the floor level of the bridge then the bridge is known as stiffened suspension bridge.

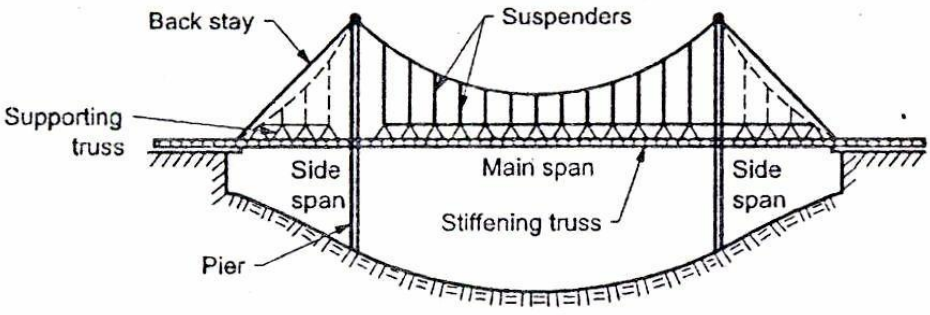


Fig. 3.14.23 : Suspension bridge with stiffening truss

 Stiffening is also done by braced chains in order to make the bridge more rigid as shown in Fig. 3.14.24.

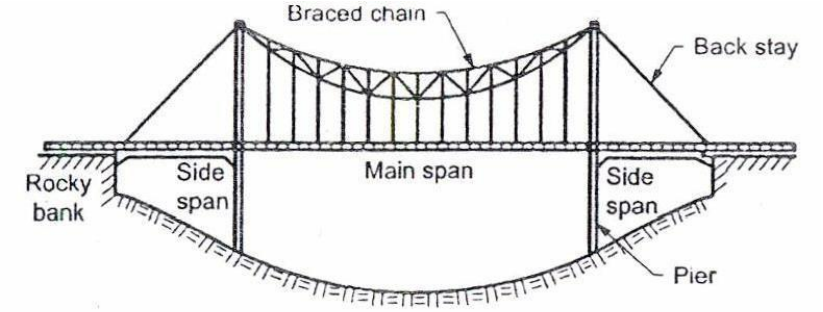


Fig. 3.14.24 : Suspension bridge with braced chains

- **Advantages of steel suspension bridge**
  1. Easy to construct.
  2. The design is comparatively simple.
  3. They are light in weight.
  4. They are light in weight.
  5. They are economical.
  6. They provide good architectural appearance.

- Such type of bridge is suitable for light as well as heavy traffic for large span between 600 to 1200 meters.

(9) Steel Cantilever bridges:

- The bridges having their superstructure consisting of cantilever trusses which carry the bridge floor is known as steel cantilever bridge.
- A cantilever bridge is formed of the cantilevers projecting from the supporting piers.
- The ends of a cantilever bridge are treated as fixed.
- Types of cantilever bridge
  a. Simple cantilever bridge
  b. Balanced cantilever bridge

a. Simple cantilever bridge:

- **Definition:** The ends of the cantilever just meet at the centre of span as shown in Fig. 3.14.25 is known as simple cantilever bridge.

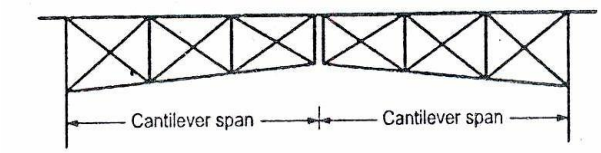


Fig. 3.14.25 : Cantilever bridge with simple construction

b. Balanced cantilever bridge:

- **Definition:** When the hinges are provided at the point of contraflexure of a continuous span and an intermediate simply supported span is suspended between these two hinges then such bridge is known as balanced cantilever bridge.

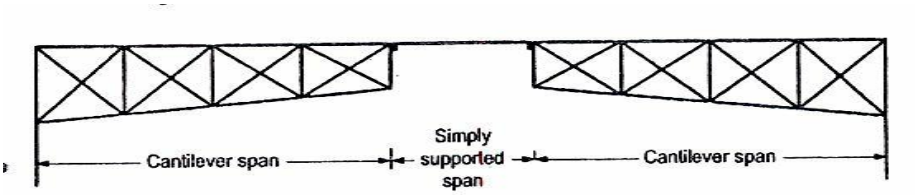


Fig. 3.14.26 : Cantilever bridge with balanced type construction

- Steel cantilever bridges are suitable over navigable rivers as they permit long spans for navigation.

10. Movable steel bridges:

- **Definition:** The iron and steel bridges which consists of movable superstructure in a part or whole are known as movable steel bridges.
- Movable bridge serves two purposes at the sametime i.e. it permits traffic over and movement of ship across its super structure.
- Types of movable steel bridges:
  Movable steel bridges are classified into following types:
  a. Swing bridges
  b. Traverser bridges
  c. Transporter bridges
  d. Bascule bridges
  e. Lift bridges.

(a) Swing bridges:

- In this type of movable steel bridges, the superstructure can be rotated in horizontal can be rotated in horizontal plane on vertical axis.
- Whenever the ship or streams cross the bridge, its superstructure is rotated through an angle of 900 by means of mechanical or electrical power on the disc bearing.
- As soon as the ship passes, super structure is brought back and locked in its original position to allow the traffic to pass over it.

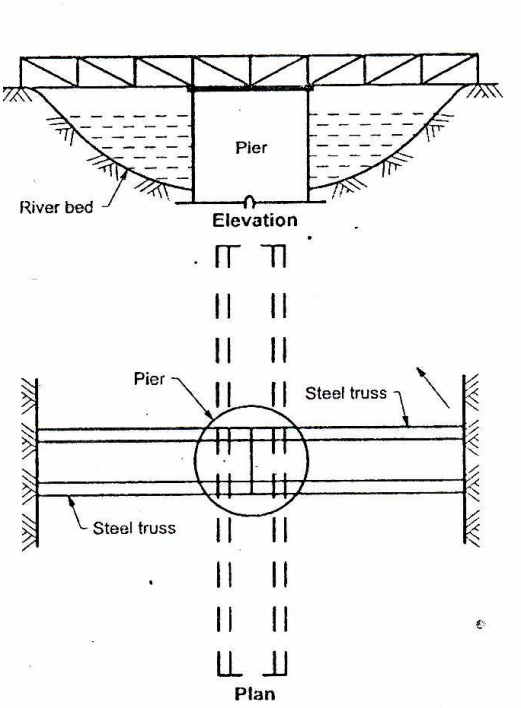


Fig. 3.14.27 : Swing bridge

(b) Traverse bridges:

- In this type of movable steel bridge, the superstructure can be rolled forward and backward across the stream to make sufficient gap for the ship to pass across.

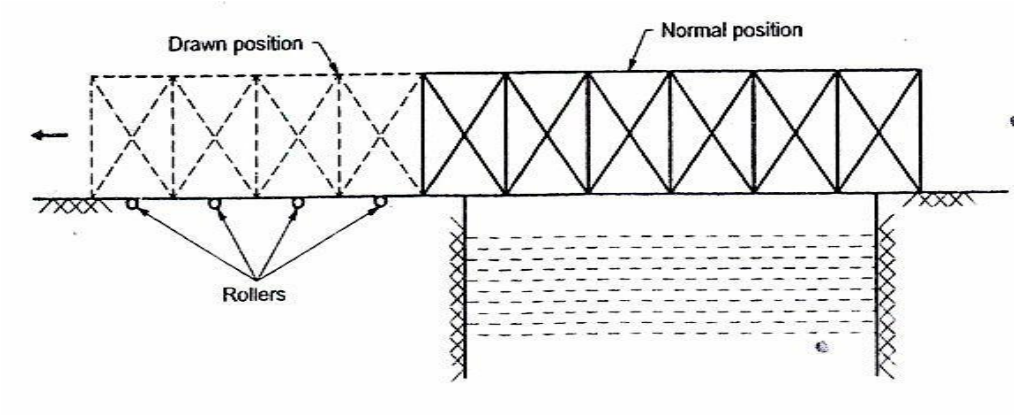


Fig. 3.14.28: Traversing Bridge

- As soon as the ship passes, it is moved backward in its original position b y mechanical or electrical power.

(c) Transporters bridges:

- It consist of a travelling cage which is suspended by cable from a solid or open type steel girder resting on the top of two towers at the bank.
- Travelling cage moves from one bank to other.
- This type of bridge does not provide through traffic

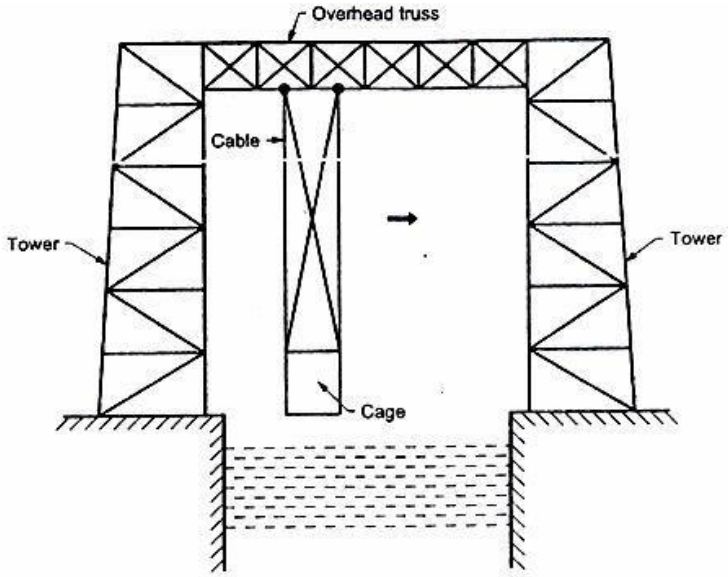
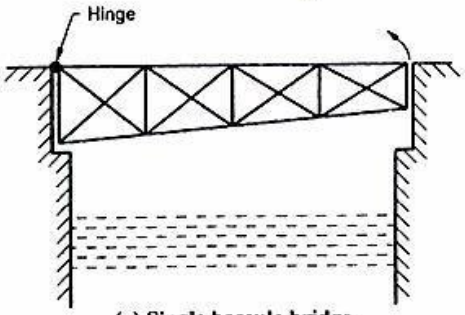
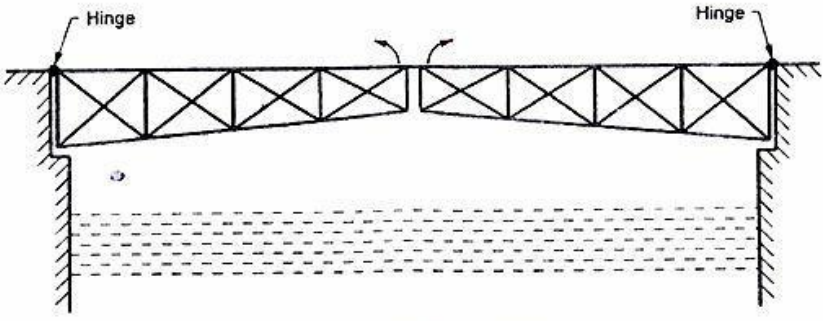


Fig. 3.14.29 : Transporters bridge

(d) Bascule bridges :



(a) Single bascule bridge



(b) Double bascule bridge

Fig. 3.14.30

- In such types of bridge, the superstructure can be moved up vertically on a horizontal hinge provided on the abutment and occupies an upright position when the bridge is open.
- Bridge may consist of single or double leaf depending upon the span of bridge.

3.14.5 R.C.C. Girder Bridge:

- **Definition:** The bridge having its superstructure consisting of R.C.C. girders and slab which supports the bridge floor is known as R.C.C. girder bridge.
- R.C.C. girder bridge is suitable for span between 10 to 20 meters.
- In such types of bridge the flooring is carried by two or more R.C.C. main girders, supported on abutments and piers with R.C.C. slab on their top.
- **Types of R.C.C. Girder bridges**

R.C.C. girder bridges are classified into following types:

1. Parapet girder bridges
2. T-beam bridges
3. Hollow girder bridges

(1) Parapet girder bridge:

- **Definition:** When main supporting members are parapet girders with thick R.C.C. slab or transverse beam with thinner R.C.C. slab, cast monolithically with tee parapet girder at their bottom, such R.C.C. bridge are known as parapet girder bridge.
- It is used for roadway bridge with narrow width.
- It is generally used for pedestrian traffic.

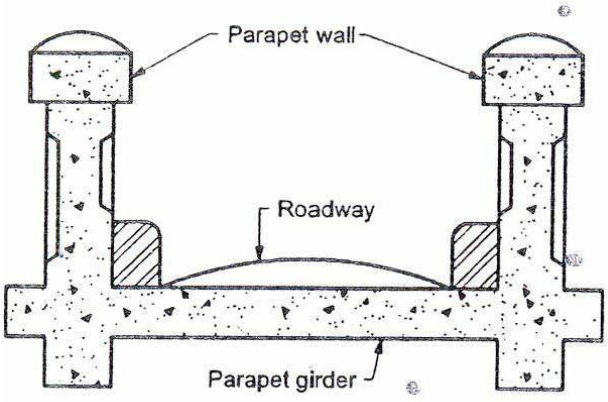
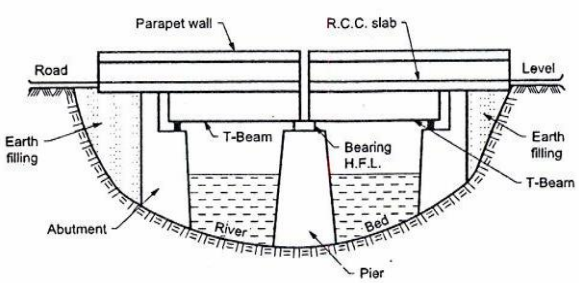


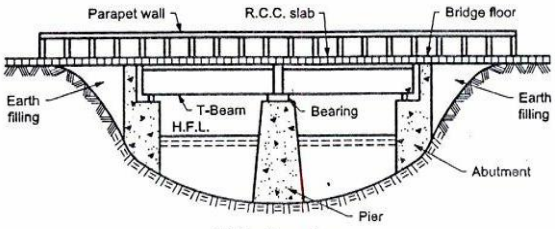
Fig. 3.14.31 : Parapet girder type

(2) T-beam bridges:

- **Definition:** When the main supporting members are T beams then such R.C.C. girder bridge is known as T-beam bridge.
- The T-beams may be simply supported, continuous, cantilever etc.
- They can be used for spans greater than 45m.



(a) R.C.C. T-beam and slab bridge



(b) Tee-beam type

Fig. 3.14.32 : T-beam bridge

(3) Hollow girder:

- When closed box-sections of R.C.C. girders are used which may be made multi-cellular of rectangular or trapezoidal shaped cells than such R.C.C. girder bridge is called Hollow girder.

- Such bridges are economical for spans between 25 to 30 meter.

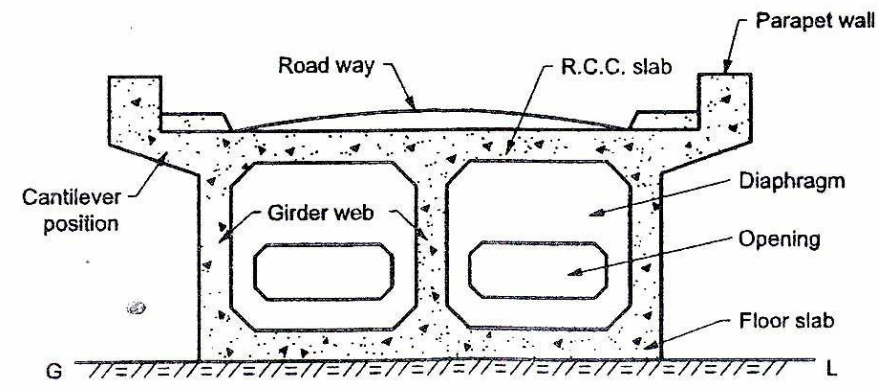


Fig. 3.14.33 : Hollow girder

3.14.6 Prestressed Girder Bridge:

- **Definition:** The bridge having their superstructure consisting of prestressed concrete members in any structural form, which support the bridge floor are known as prestressed concrete bridge.

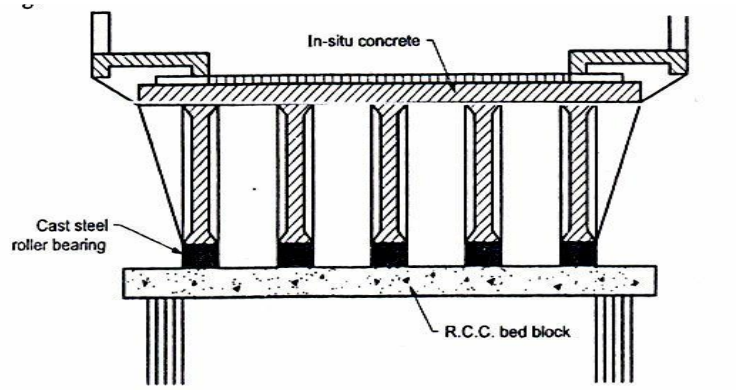


Fig. 3.14.34 : Prestressed girder bridge

Advantages:

1. They have the fewer expansion joint.
2. They have lighter construction.
3. They have the higher load carrying capacity.
4. They have reduced deflection of girders.
5. Their maintenance cost is less.
6. They have better resistance to fatigue due to elimination of cracking of its members due to the heavy traffic load.
7. They have reduced deflection of girders.
8. They provide more smooth deck for high speed driving.
9. Their aesthetic appearance is good.

- **Disadvantages:**

1. Prestressed concret members requires high tensile steel, which is much Costner than ordinary mild steel.
2. Skill supervision is required.
3. More special equipment are used in the construction.

- Such types of bridge are specially suitable as 'urban highway bridges'.
- It is suitable for long span.

3.15 Temporary Bridges:

- **Definition:** The bridges which can be constructed as well as maintained at low cost and have short span of useful life are known as temporary bridges or low cost bridges.

3.15.1 Timber Bridges:

Definition:

The bridges having their superstructure and substructure made of timber members are known as timber bridges.

- Timber bridges are suitable in hilly areas or where a good quality of timber is largely and cheaply available.
- Because of following limitations timber brides are not popular:

a) Their life is short (10 to 15 years)
b) The timber is easily liable to catch fire.
c) They are used only for short span bridge.
d) The strength of timber is not uniform in all direction.
e) The timber is susceptible to decay or disintegration under the effect of weathering agencies.

Types of timber bridges:

a) Timber bridges with intermediate support:
(i) Timber trestles
(ii) Pile bents
(iii) Cribs
(iv) Crates.
(b) Timber bridges without intermediate support:
(i) Timber cantilever bridge
(ii) Timber suspension bridge
(iii) Timber trusses bridge

Timber bridges with intermediate support:

For the temporary bridges following intermediate supports are used :

Timber trestles:

- These are usually constructed of sal wood ballies, round or square in sections or form tree trunks when heavy section in required.
- Trestle with round sections are fixed together by ropes of steel wire at their joints. The diagonal braces are provided in between transom and ledger.
- The trestles may either be two legged, three legged or four legged.
- Trestles are used as piers of timber bridges when the bed of the stream is sufficiently hard and the depth of water as well as velocity is not more.

- **Timber bridges without intermediate support:**

The temporary bridges may be designed to span the full width of river or stream with the help of the following:
(1) Trusses
(2) Cantilevers
(3) Suspension

(1) Trusses:

- The trusses can be used to construct long span timber bridges.

With the help of timber trusses it is possible to construct timber bridges for spans upto 14m to 18m.

- Following Fig. 3.15.1 show some of the timber trusses:

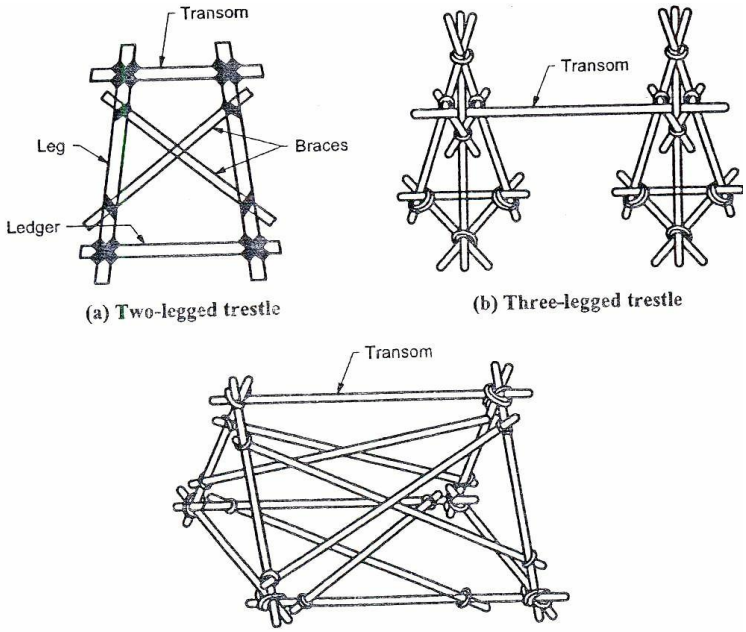
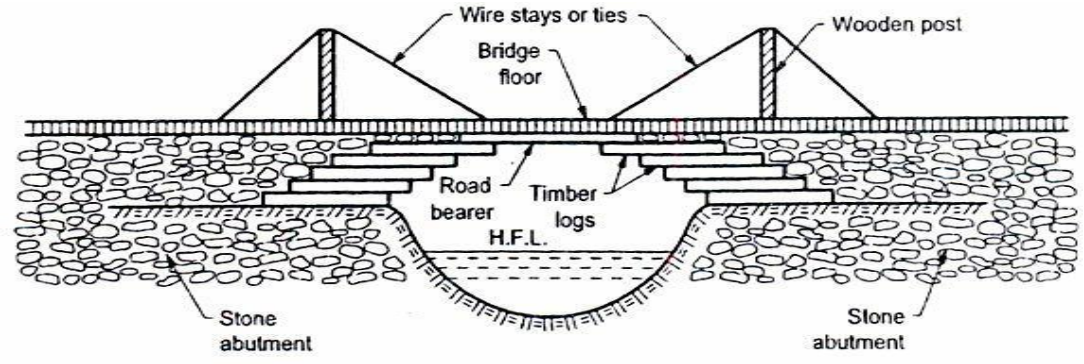


Fig. 3.15.1 : Different types of timber trestles

(2) Timber cantilever bridge:

 In case of timber cantilever bridge, the layers of timber logs are projected from each bank such that each layer projects about 1.5 m to 3 m from the layer just below as shown in Fig. 3.15.2.



Timber cantilever bridge

Fig. 3.15.2 : Cantilever bridge

 The timber cantilever bridges are very much useful and economical in the hilly areas where the timber is easily available and traffic is light.

(3) Timber suspension bridge:

- For crossing small streams or valleys, the timber suspension bridges may be provided in the hilly area.
- The bridges can take up light traffic are usually not stiffened.
- **Types of timber suspension bridge:**

Following are the three types of timber suspension bridges:

(a) Rap bridge
(b) Sling bridge
(c) Trestle suspension bridge

(a) Ramp bridge:

- This is a very cheap type bridge as it requires a less quantity of material and can be constructed in a very short time.
- As the bridge is connected with the banks by ramps, it is known as ramp bridge.
- The bridge floor consists of wooden planks.
- The only disadvantage of this type of bridge is that it does not possess stiffness and hence it is distorted when the traffic moves over it.

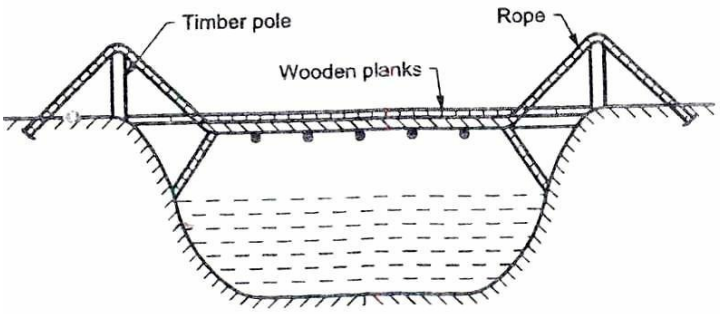


Fig. 3.15.3 : Ramp bridge

(b) Sling bridge:

- In case of a sling bridge, the roadway is supported on rope slings or cables.
  In bridge floor consists of wooden planks which are supported at their ends on wooden beams.
- Wooden beams are provided on either side of roadway.
- The wooden beam is connected to the cable through suspenders.
- The cables are taken over the towers and then anchored into the ground

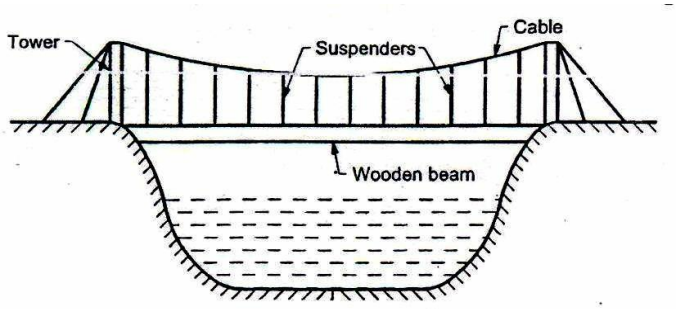


Fig. 3.15.4 : Sling bridge

(c) Trestle suspension bridge:

- In this type the roadway is provided on trestles, which are supported on cables.
- They are economical upto span of 8 m.
- Such type of bridge does not distort under traffic.
- But it has also the disadvantage of having a very heavy weight and it is costlier than ramp bridge.

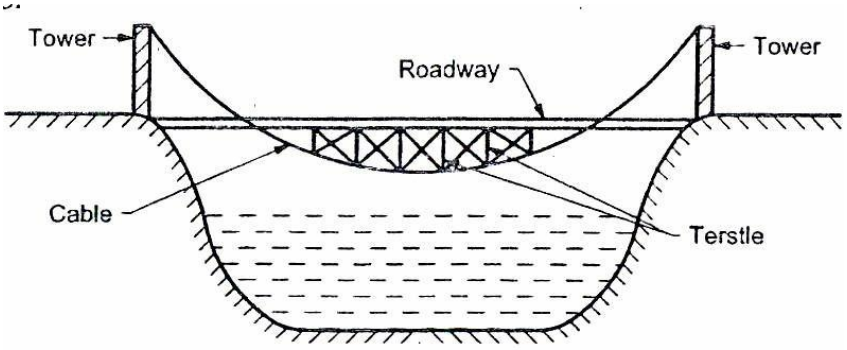


Fig. 3.15.5 : Trestle suspension bridge

3.15.2 Flying Bridges:

- **Definition: The** bridges consisting of ferry boats or rafts which are usually rowed or peled across the bank of stream or river are known as flying bridges.
- This are temporary movable bridges.
- They do not span the whole width of the stream of river.
- A flying bridge is suitable when sufficient funds and materials are not available to make regular bridge.

Types of flying bridges:

In flying bridges, the ferry i.e. boat or raft may be any one of the following methods:

1. By using warp
2. By using anchors and swinging cables.
3. By using a suspension cable.

1. By using a warp:

- The bridge consists of cable or warp which is stretched tightly across the cannel .
- The cable moves through the rollers fixed on the raft.
- For return journey, another set of rollers is provided.

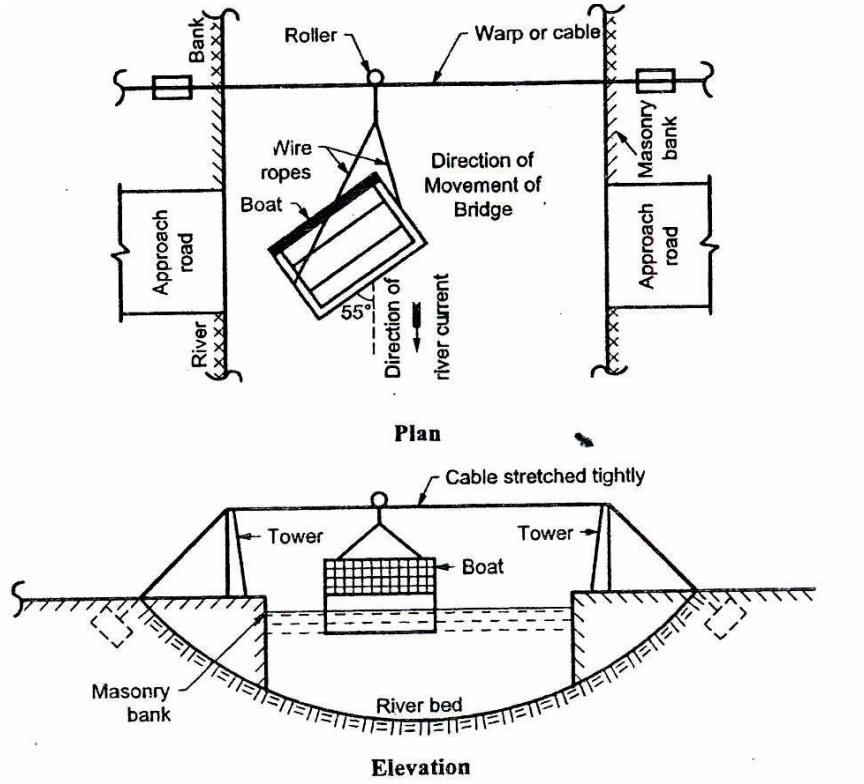


Fig. 3.15.6 : Flying bridge with a warp

2. By using anchors and swinging cables:

- In this method, the flying bridge consists of a cable provided in the centre of bridge span in the direction of the river.
- One end of the cable is supported on a boat or float of casks and is anchored to the river bed.
- The other end is connected to the ferry (a boat or raft) as shown in Fig. 3.15.7
- In this case the length of rope should be 1.5 to 2 times the width of river.

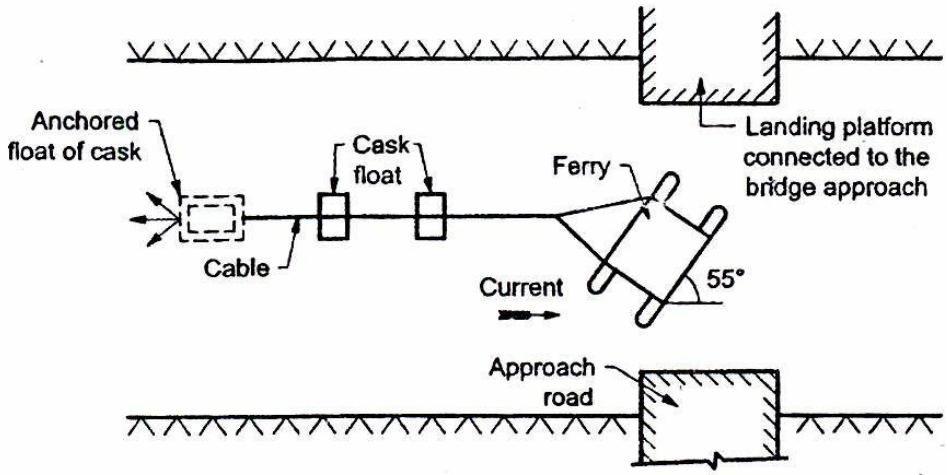
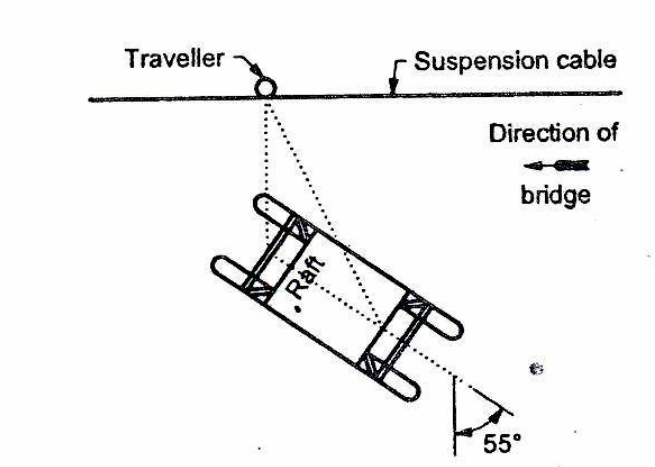


Fig. 3.15.7 : Flying bridge with anchors and swinging cables

3. By using a suspension cable.

- In this method, the flying bridge consists of a raft which is rowed by means of two wires, attached to the traveler, running over the suspension cable as shown in Fig. 3.15.8.
- In this type, the raft is generally kept in such a position that its length makes an angle of 550 to the direction of stream so as to make use of water current while rowing the raft from one bank to the other in a straight path.
- The ends of the wires are interchanged for the return journey of the raft.



3.15.8 : Flying bridge with a suspension cable

3.15.3 Floating Bridge:

- **Definition:** The bridge having their substructure floating on the water surface of a stream of river are known as floating bridge.
- Types of floating bridges:
  1. Boat bridges
  2. Pantoon bridges
  3. Raft bridges.

1. Boat bridges:

- In floating bridges, number of boats are used for making the bridge substructure.
- The boats are fixed with gunwale pieces to serve as bearing plates for trussed beams called gunwales, with planks over them.
- This gunwales are fixed to gunwale pieces, provided on the outer edges of two adjacent boats.
- Cross beam with transverse planks is provided over them; which are notched to the gunwale pieces of the same boat.
- Anchors are used on the upstream and down stream side to held the boats in position.
- Anchors are used on the upstream and down stream side to held the boats in position.

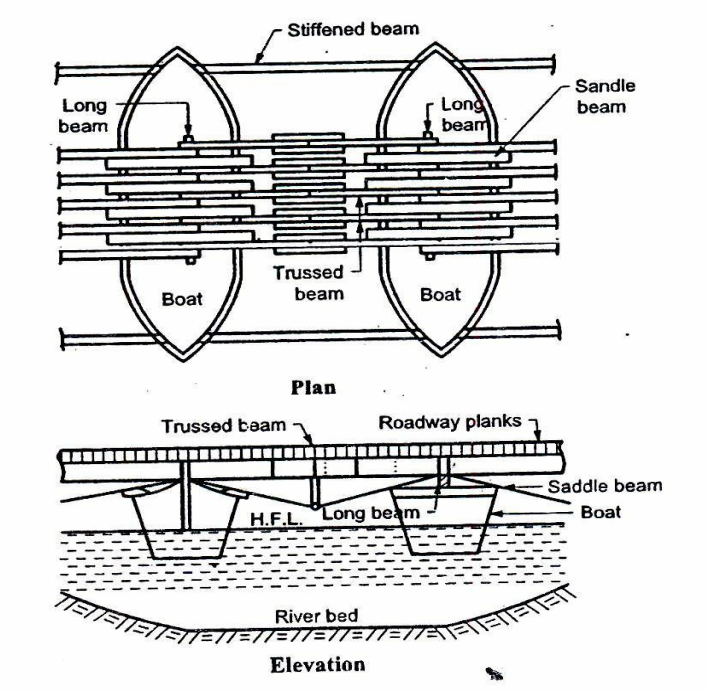


Fig. 3.15.9 : Boat bridge

2. Pontoon bridges:

- In such type, a number of pontoons are used for making the bridge substructure.

- Usually cylindrical sheet-iron pontoons are used to support bridge superstructure.
- The pontoons are provided with inside trussing and are held together by double bolted beams to form the rafts.

- Cross beams are placed along the length of pontoons, to keep the rafts together.
- The bridge floor is then provided on such rafts with longitudinal beams.
- These bridges are superior to boat bridges regarding their strength and durabilit y.

- Also they can resist heavy current of water and take more load.
- They have disadvantage that they are heavier and expensive is their initial cost than boat bridges.

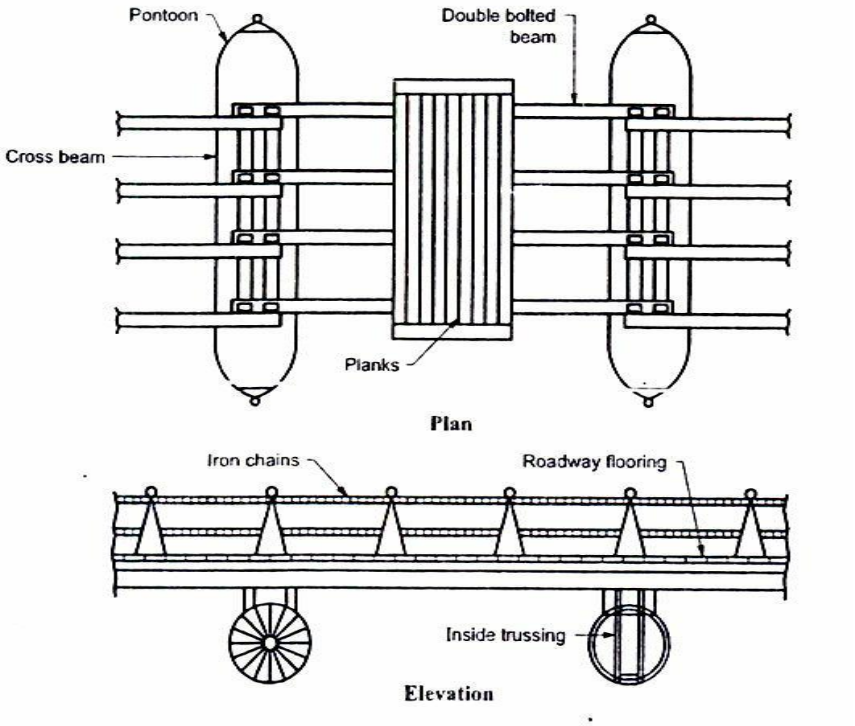


Fig. 3.15.10 : Pontoon bridge

(3) Raft bridge:

- A raft bridge indicates a bridge made of rafts.
- A raft is a flat floating mass of wooden logs.
- The substructure consists of floating piers made of barrels or casks which are connected to the gunwales at their top.

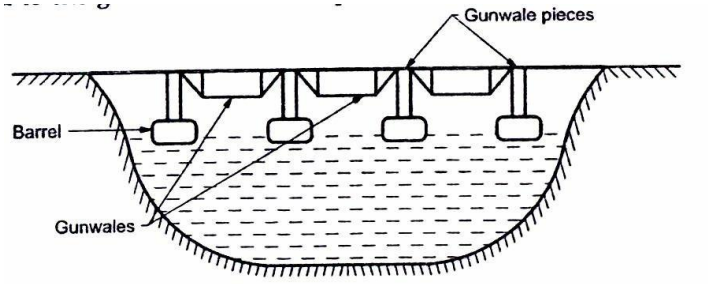


Fig. 3.15.11 : Raft bridge

3.16 Inspection and Maintenance of Bridge:

3.16.1 Maintenance of Bridge:

- **Definition:** The art of upkeeping the bridge components in good condition to keep the bridges in best serviceable order for a longer period is known as bridge maintenance or maintenance of bridges.

- **Necessity of bridge maintenance:**

(1) After the bridge is constructed and opened to traffic, its components such as foundations, pier, abutments, wing walls, approaches, flooring system, railing etc are subjected to damages due to so many reasons. Therefore it is necessary to maintain bridge in such condition that it function properly.

(2) Maintenance of bridge becomes essential to keep them in best serviceable condition for a longer period.

3.16.2 Classification of Bridge Maintenance jobs:

The maintenance of bridges can be broadly classified into the following two types:

1. Routine maintenance
2. Special maintenance

1. Routine maintenance:

- **Definition:**

The maintenance work which is carried out regularly on the basis of routine inspection is known as routine maintenance.

- This type of maintenance is carried out annually after general routine inspection in order to rectify defects of general character.
- Routine maintenance of bridges includes the following maintenance jobs:

1.To check proper functioning of weep holes.

2.To check proper functioning of drainage devices.
3.To check proper functioning of bearings and expansion joints.
4.To repairs the defective piers and abutments.
5.Maintenance of water proofing coats.
6.Maintenance of wearing coat of the bridge floor

7. Maintenance of kerbs, railings etc.
8. Careful examination of steel structures for corrosion and developments of cracks.

(2) Special maintenance:

 Definition: The maintenance work of special character which is carried out after certain period on the basis of detailed inspection is called special maintenance.
 This type of maintenance is carried out, once in 3 to 5 years, after detailed visual examination of all bridges components in order to rectify defects of special character.
 Special maintenance of bridges includes the following maintenance jobs:

1. To check and rectify the foundation and movements.
2. To check and repair damaged members.
3. TO repair the cracks in concrete and metal work.
4. To check the loose connections.
5. To check the area of past repairs.
6. To repair the exposed reinforcement.

Inspection of Bridge:

 It is necessary that every part of the bridge structure is kept under constant observation. For this purpose, inspection is done by well qualified and experienced engineers.

 The regular inspection of bridge is of great importance, since the early detection of trouble and prompt attention may avoid costly repairs.

 The following points should be kept in view while inspecting a bridge:
1. Behaviour of expansion joints.
2. Condition of concrete work.
3. Condition of wearing coat and its thickness.
4. Condition of reinforcement.
5. Any sign of development of cracks in concrete abutmetns and piers.
6. Any sign of settlement of foundations.
7. Any sign of scour along with maximum depth of scour.
8. Conditons of paints.
9. Condition of parapet walls.
10. Condition of kerbs and railings.

Classification of inspection work:
The inspection work can be classified into following two types:
1. Routine inspection
2. Detailed inspection.

1. Routine inspection work:

Definition: The inspection work which is carried out at regular intervals for the general examination of structure is known as routine inspection.

 It is generally done for short span bridges.
 Usually routine inspection is conducted prior to the monsoons.

2. Detail inspection:

 The detailed inspection includes the visual examination of all the components of bridge .
A check list of itmes is inspected either visually or with the help of standard instrument is prepared.

 The structural analysis of bridges is done by experienced bridge design engineers.
 It is carried out once in two years.