UNIT - 03

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BRIDGE

* Bridge *

* **Bridge :-** Bridge is that structure which facilitates a communication route over a depression or obstruction such as river, stream, channel, road or railway.

The communication route may be a railway track, roadway, tramway, footpath, cycle track or combination of them.

* **Consideration ~~of~~ in site selection :-**

(1.) Suitable unyielding (~~-ह~~ [illegible]) and non-erodable materials for foundation should be available.

(2.) The stream at bridge site should be well defined and as narrow as possible.

(3.) There should straight reach of stream at bridge site.

(4.) The banks of river should be firm, permanent and ~~हाइ~~ high at bridge site.

(5.) There should be no intersection of large tributories near by the bridge site.

(6.) There should be easy availability of labours,

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Construction material and transport facilities near by the site.

(7.) The Bridge site should be such that no excessive work is done inside the water.

(8.) The site should be such that there is direct alignment of road i.e., the road cross the river at right angle.

(9.) There should be sufficient vertical height b/w bridge and H.F.L (Highest flood level) for navigation purpose.

(10.) The bridge should not be on curved portion of river.

✱ Classification of bridge :-

1. On the basis of life of bridge :-
   (a) Permanent bridge
   (b) Temporary bridge

2. On the basis of construction material :-
   (i) Timber bridge
   (ii) Masonry bridge
   (iii) Steel bridge
   (iv) R.C.C bridge
   (v) Prestressed concrete bridge

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On basis of position of Highest flood level (H.F.L):-
(a) Submersible Bridge
(b) Non-Submersible Bridge

On basis of alignment
(i) ~~Foot path bridge~~ Straight bridge
(ii) Skew bridge

On basis of function:
(i) Foot path bridge
(ii) Railway bridge
(iii) Highway bridge
(iv) Viaduct (bridge on dry velly)
(v) Aqueduct

On the basis of length of span
(i) Culvert < 6m
(ii) Minor bridge 8m to 30m
(iii) Major bridge 30m to 120m
(iv) Long bridge more than 120m

Component parts of bridge:-

The bridge structure may be divided into two major parts:-
(i) Sub-structure
(ii) Super structure

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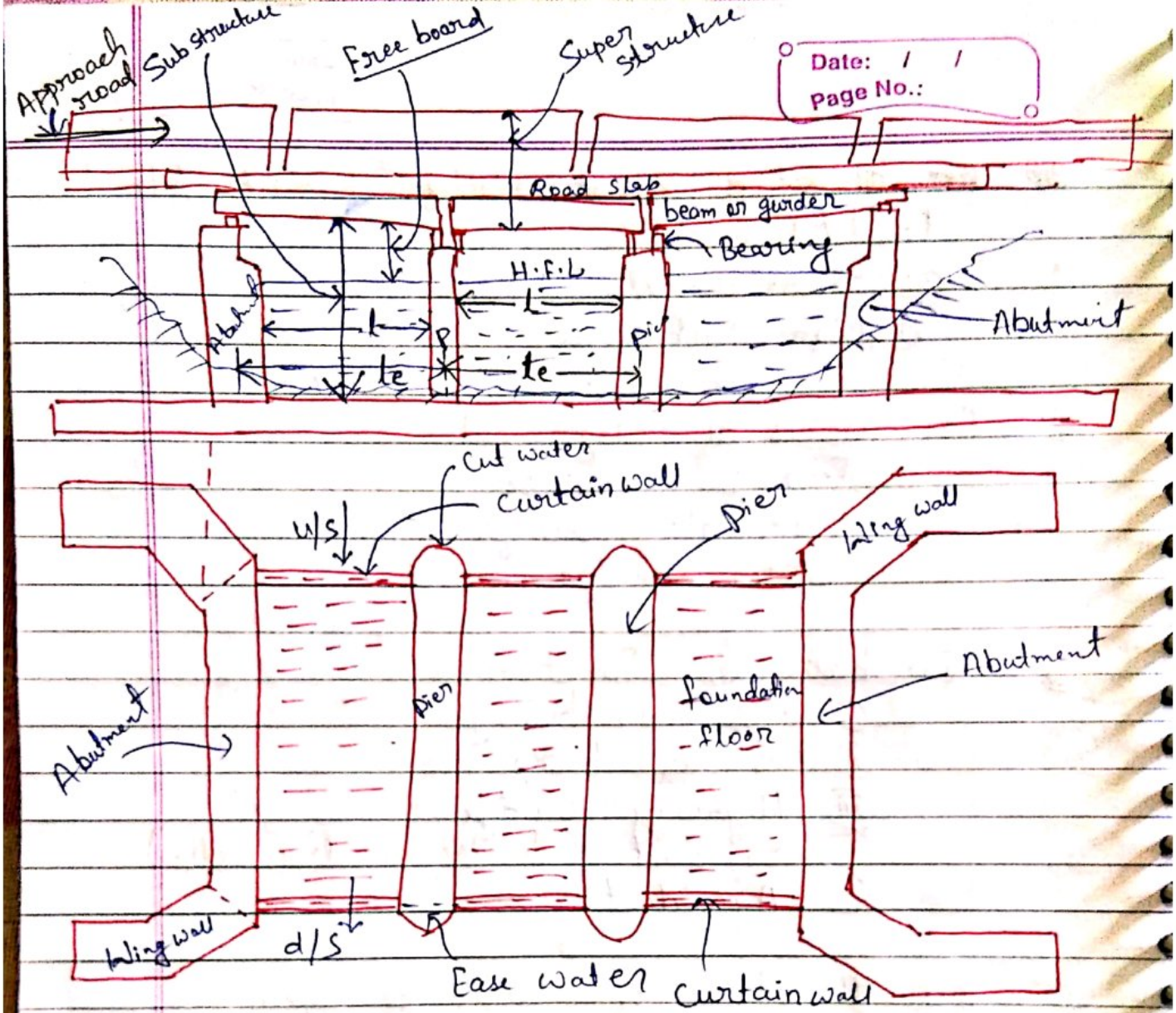

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- Substructure elements are
  - I. Foundation
  - II Abutment & Wingwalls
  - III. Piers along with cut water & ease water.
  - IV. Curtain walls.
  - V. Approaches.

* Superstructure consist.
  - I. Beam, girder or arch, trugs
  - II. Road surface
  - III. Hand rail & parapet wall.

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Definition of terms related to bridge

Clear span :- The clear horizontal distance (d) b/w faces of two successive piers or b/w the faces of one pier and the face of abutment is called clear span.

Effective span :- The Centre to centre distance (le) b/w two successive piers is called effective span.

Economical Span :-

Economical span of a bridge is that span for which overall cost of bridge comes to be minimum.

It is found that for most economical span, the cost of super structure = Cost of sub-structure

Water way or Linear water way :-

The linear water way of a bridge is the length available for flow of water b/w two extreme edges of water surface during the highest flood level measured at right angle to abutment.

Effective water way = Total linear water − Sum of thickness of piers.

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5. Afflux :- Due to construction of bridge there is contraction in water way. This results in rise of water level above its normal level. This rise is known as afflux.

6. Scour :- The vertical cutting of bed of river or stream due to flowing water is called scour. The depth of this cutting is called scour depth.

7. H.F.L (Highest flood level) :- It is the level of highest flood ever recorded in previous 100 years.

8. Free baard :- Free board at any point is the difference b/w highest flood level (H.F.L) and the bottom of bridge superstructure.

→ It is provided for navigation purpose in large bridge and for pessess of debries in small bridge or culverts.

9. Foundation :- Foundation is the lowest ~~power~~ part of the structure which is in direct contacts with ground or sub-soil.

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* Functions of foundation :-

(i) It distribute the load of supporting system and super structure on larger area of sub-soil.

(ii) The foundation prevents unequal settlement of structure.

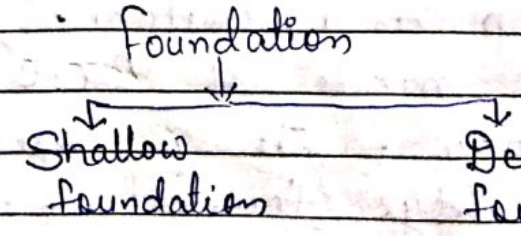
(iii) It prevent tilting of piers and abutments.

(iv) It provides a level base for construction of piers and abutments.

(v) It ~~prevent~~ provides lateral stability to structure.

(vi) It prevents overturning of piers & abutments.

* Types of foundation :-



→ Bridge foundation are deep foundations which may be of two types :-

(i) Well foundation
(ii) Pile foundation.

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→ Well foundation is the most commonly used foundation for bridge in India. Well foundation are of three types :-

Well foundation is also known as Cassion :-

(i) Box cassion
(ii) Open cassion
(iii) Pneumatic cassion

(i) Box cassion :-

Box cassion is open at top and closed at bottom. It may be made up of ~~simple~~ timber, steel or R.C.C. This box is constructed on land and lowered to location where it is required. It is suitable for shallow depth where land is not very high

(ii) Open cassion :-

Open cassion is open at both top and bottom. They are generally made of R.C.C, ~~metle~~ metal or masonary. It is used for building and bridge foundation.

Open cassion are also called well foundation.

→ Wells are different ~~siz~~. shape :-

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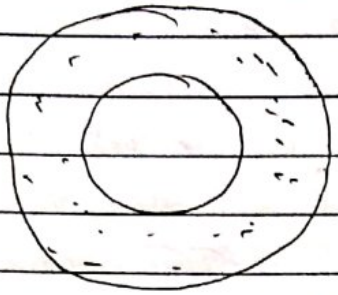
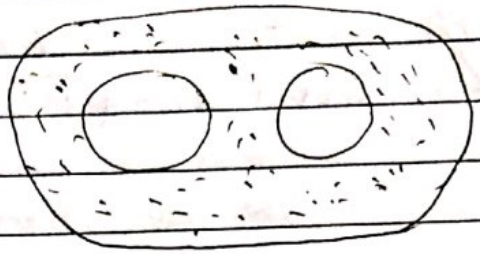
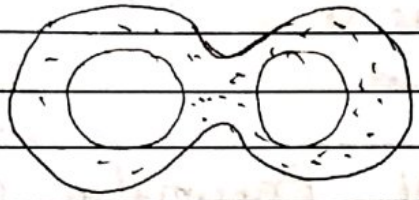
(i) Circular



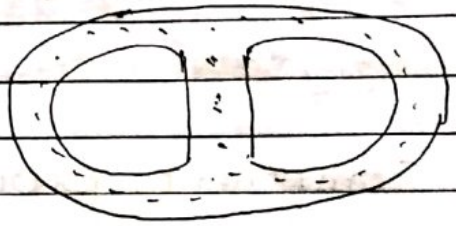
II. Twin circular



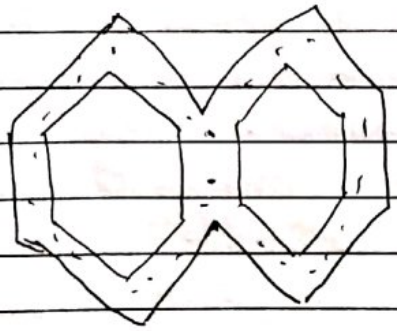
III. Dump-bell



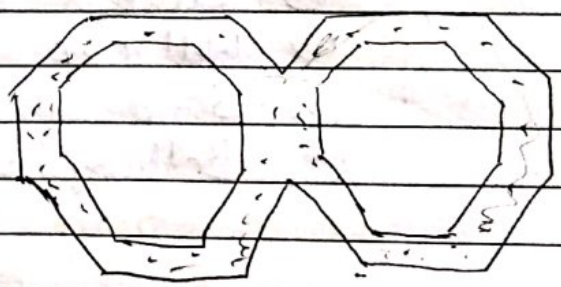
IV Double Dee



(v) ~~Depth~~ Twin hexagonal



(vi) Twin octagonal



(iii) Pneumatic cassion :-

Pneumatic ~~caisson~~ cassion are open at bottom and closed at top. In b/w closed top & open bottom pressure is regulated so that labours can work comfortably.

★ Levelled diagram of Pneumatic cassion and its component parts :-

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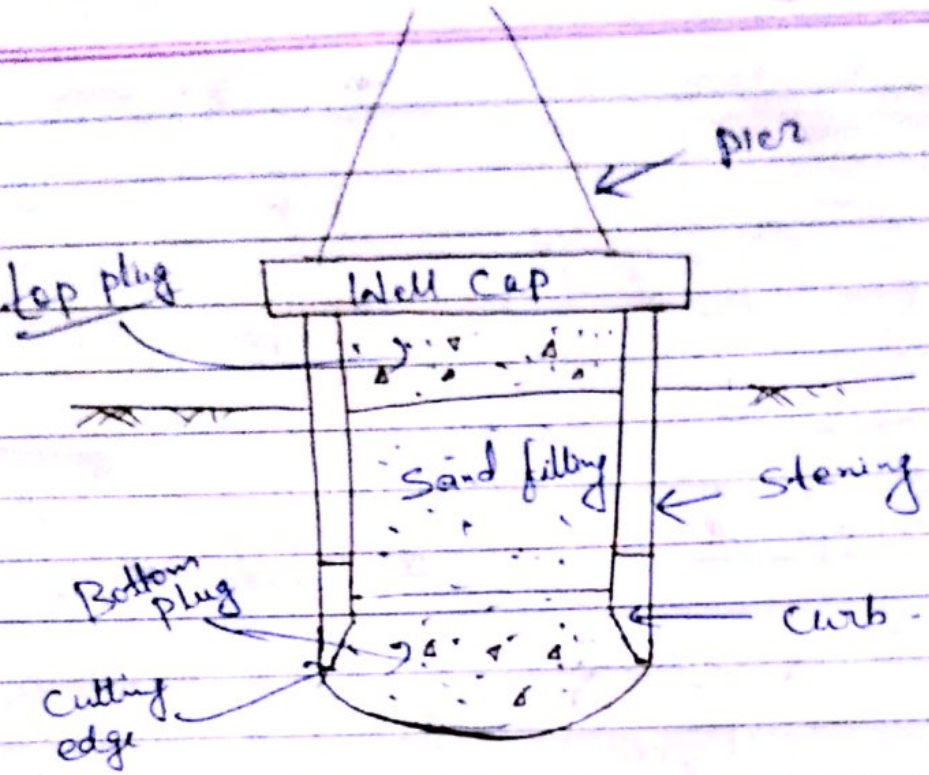

* Component parts of Pneumatic Caisson

1. Stening
2. top plug
3. Curb
4. Well cap
5. Sand filling
6. Bottom plug

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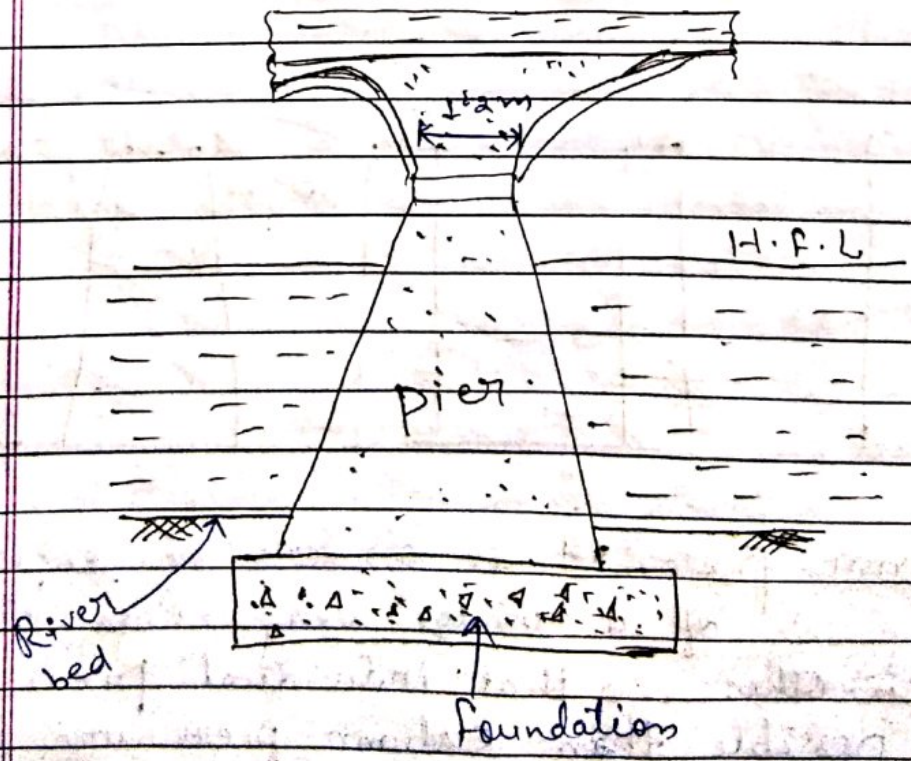
★ Piers :- The intermediate vertical supports of a bridge or culvert are called piers. There may several piers in a bridge depending upon length of the bridge. Generally piers are made of concrete or masonry.

* Function of piers :-

(i) The main function of piers is to transfer the load of superstructure of bridge to the foundation.

(ii) They ~~provided~~ divide bridge into several segments providing a number of spans.

(iii) It is capable to sustain water pressure, wind load, seismic load etc.



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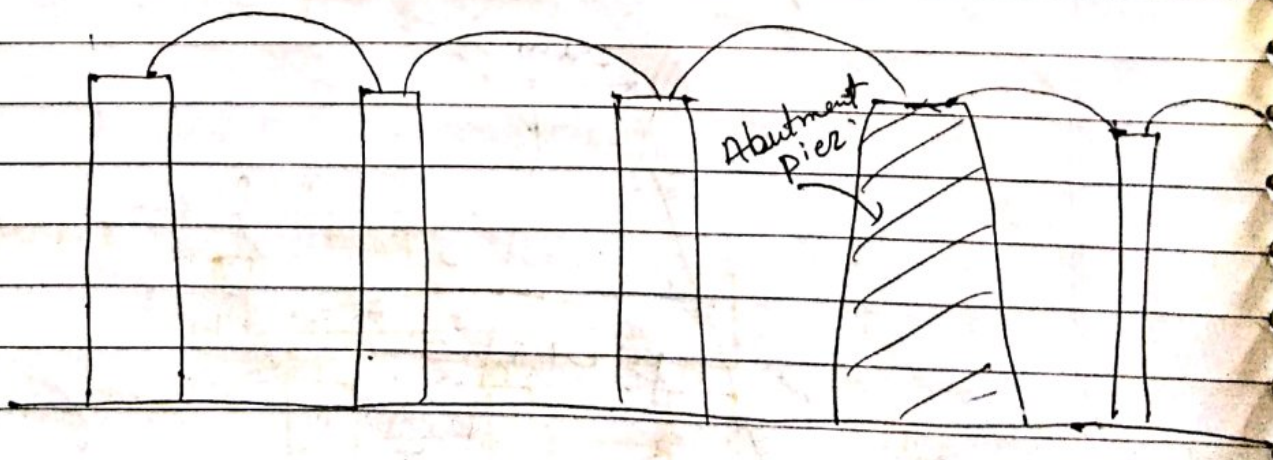
* Types of piers :-

(i) Solid Piers :-

They are made of concrete or masonry as a solid structure. They can resist the floating objects in ~~bottom~~ better way. They are suitable for any types of superstructure. Minm top width is 1·2 m and it is battered at the ratio of 1:12 to 1:24 for better stability.

(ii) Abutment piers :-

For long arch bridges, it becomes necessary to provide some intermediate piers of heavier section. These piers of heavier section are called Abutment piers. These are provided to resist horizontal thrust.



(iii) Column pier :-

When girders of superstructure of a bridge very close to each-other so that individual piers are not possible than column piers are used.

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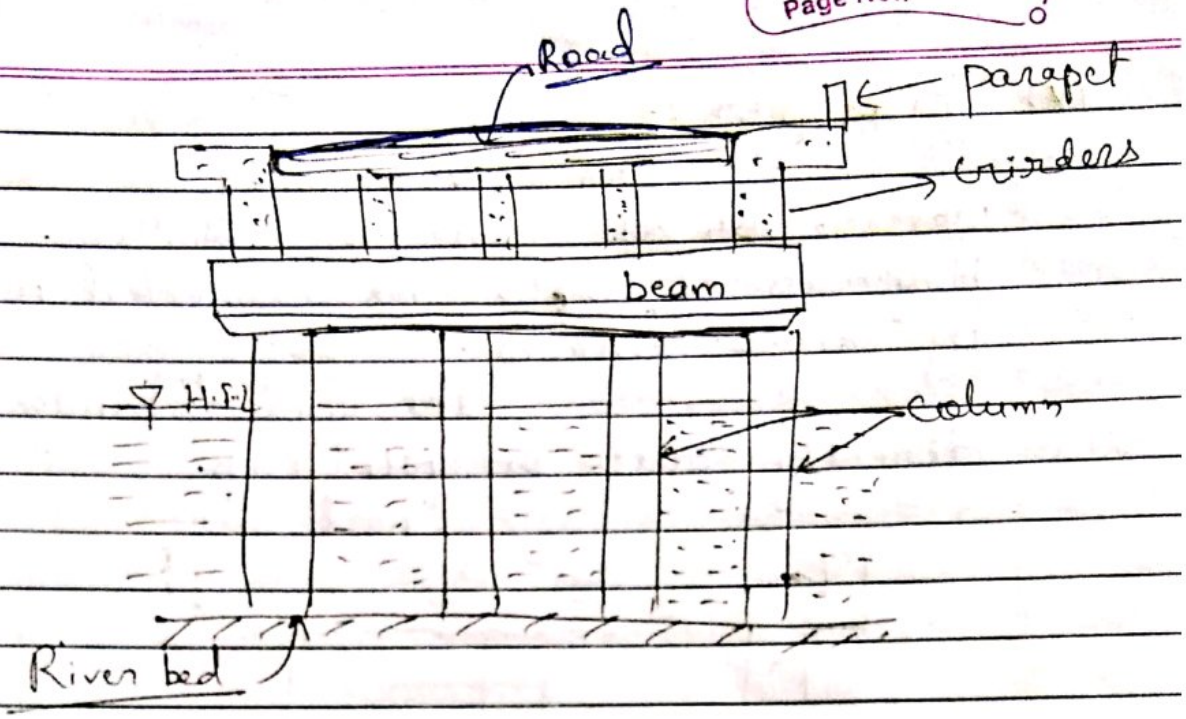
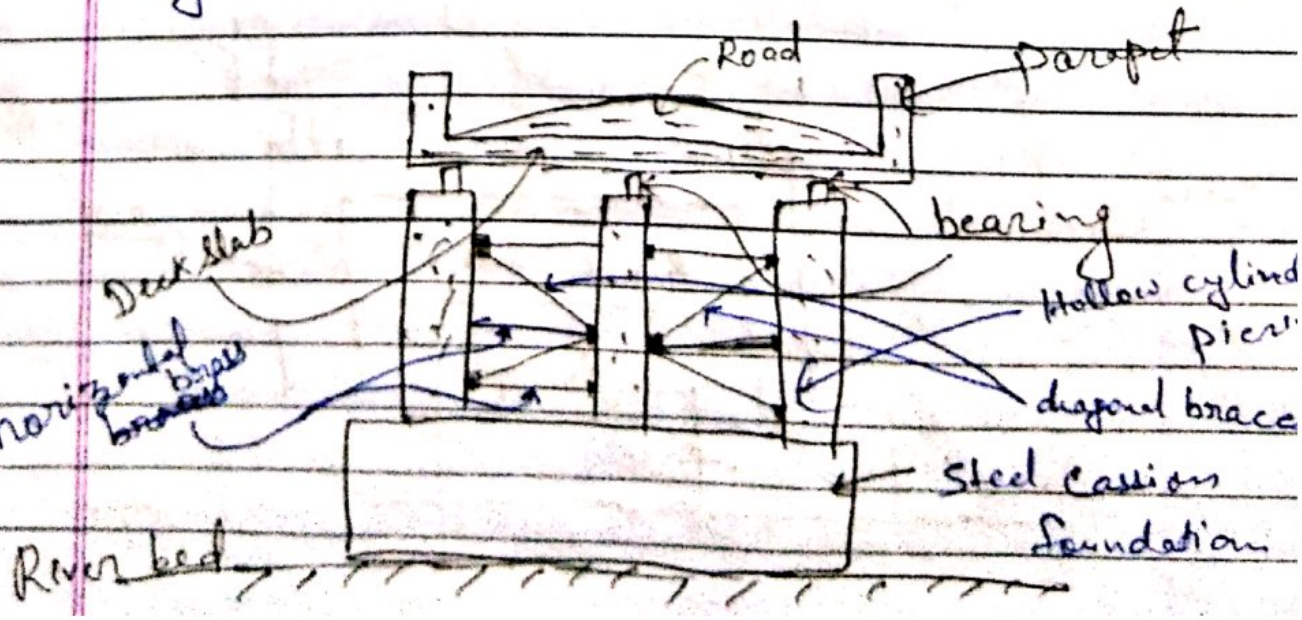


In this case a number of column are erected and beam is provided at their top which support the girder.

(iv) Cylindrical Piers :

These are hollow cylind made of cast iron or mild steel. The empty space of cylinders is filled with concrete to increase the stability. These piers connected together by means of horizontal.



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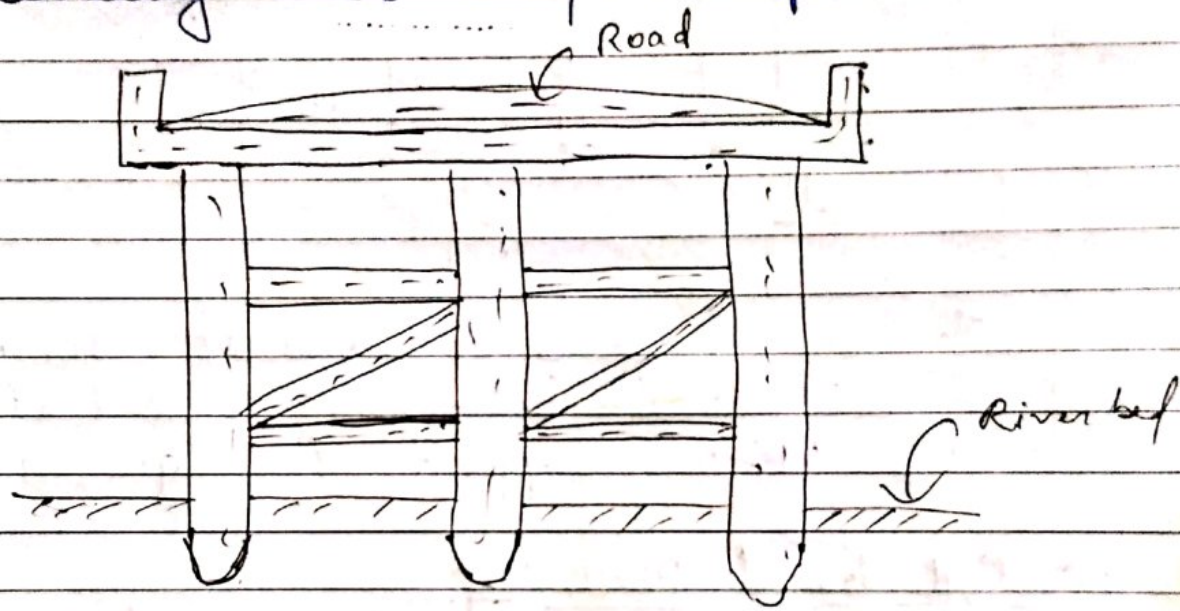
(v) Pile pier :-

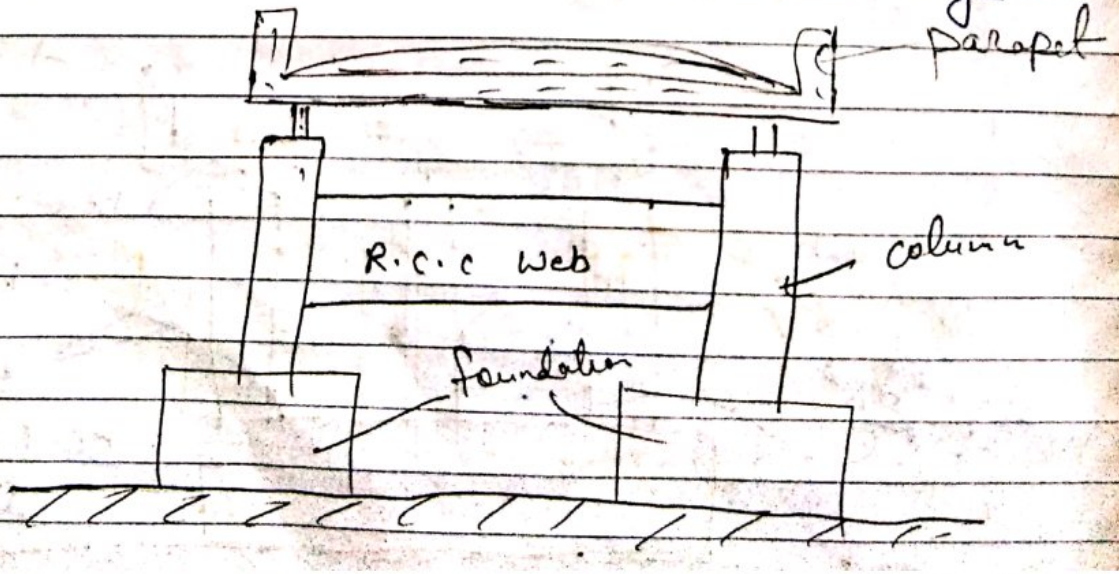
This type of pier is used where depth of water is shallow. A group of piles are connected together by R.C.C. braces.

The girder of a bridge directly rests on pile cap.



(vi) Dumb-bell Pier :-

In this case two solid R.C.C piers are connected together by means of a thin R.C.C. web in a direction transverse to the bridge.



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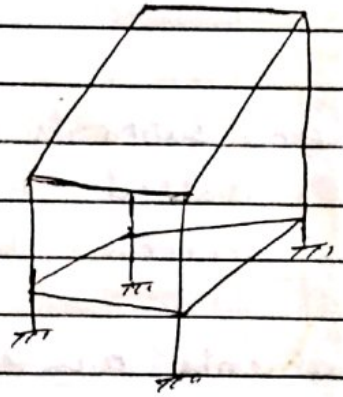
(vii) Trestle Pier :-

Threstle is a frame work of R.C.C or steel consisting of 3 or 4 legs whose top forms a plane surface.

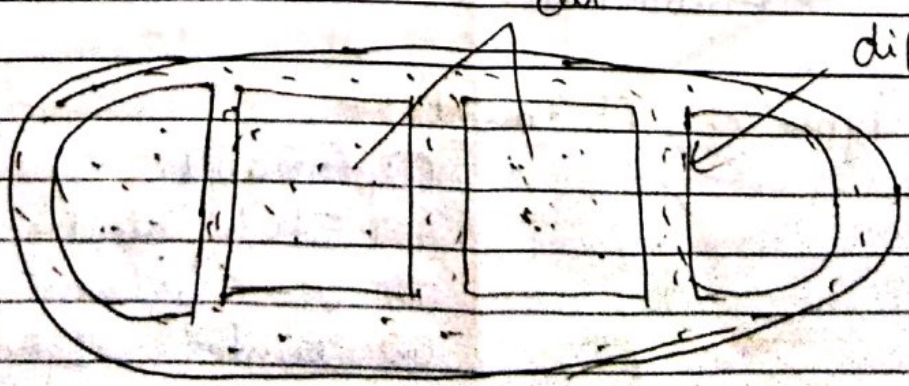
A number of such trestles are used to support the superstructure of bridge. This is suitable where water current is low.



Trestle

(viii) Cellular pier :-

It is used to receive prestressed super structure. It consist of two R.C.C cells connected by horizontal band and radial ribs at suitable intervals. The space space of cells are filled with sand.



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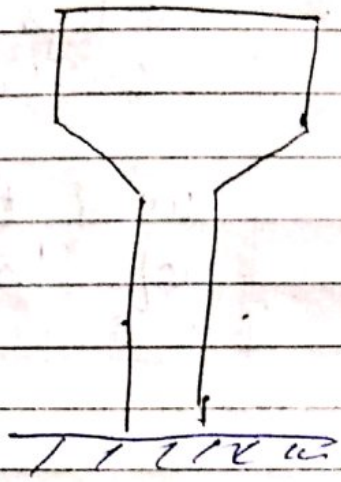
(iv) Hammer head piers :-

Hammer head pier is a single solid cross-section which support a cap major axis.



* Abutments :→

The end supports of a bridge or culvert are called Abutments. They are heavier in section than piers.

* Functions of abutments are as follows :-

(i) They support the superstructure of bridge at ends and transfer the load to foundation.

(ii) They connect the approach roads to the bridge deck

(iii) They retain the earth of road embankments.

* Types of Abutments :-

(i) Gravity abutment
(ii) Stub abutment
(iii) U-abutment
(iv) Counter abutment

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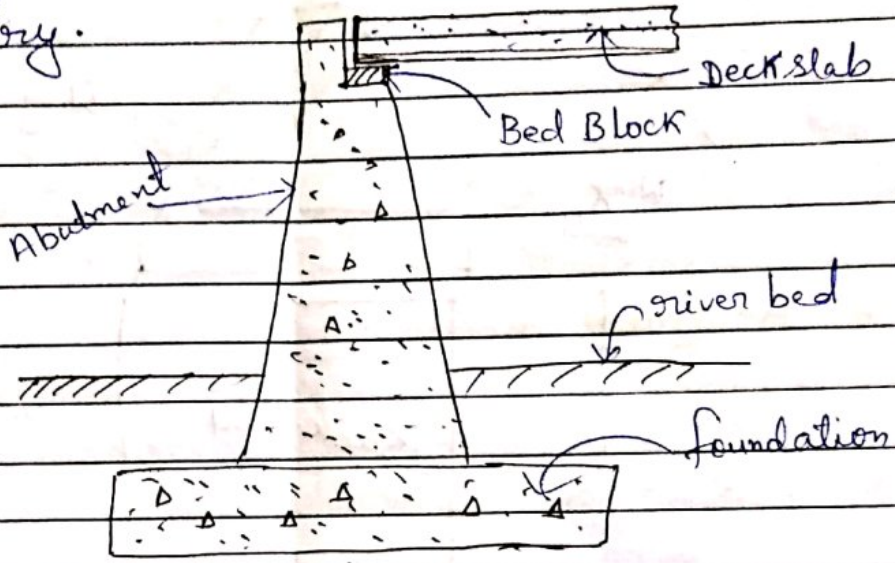
① Gravity abutment :-

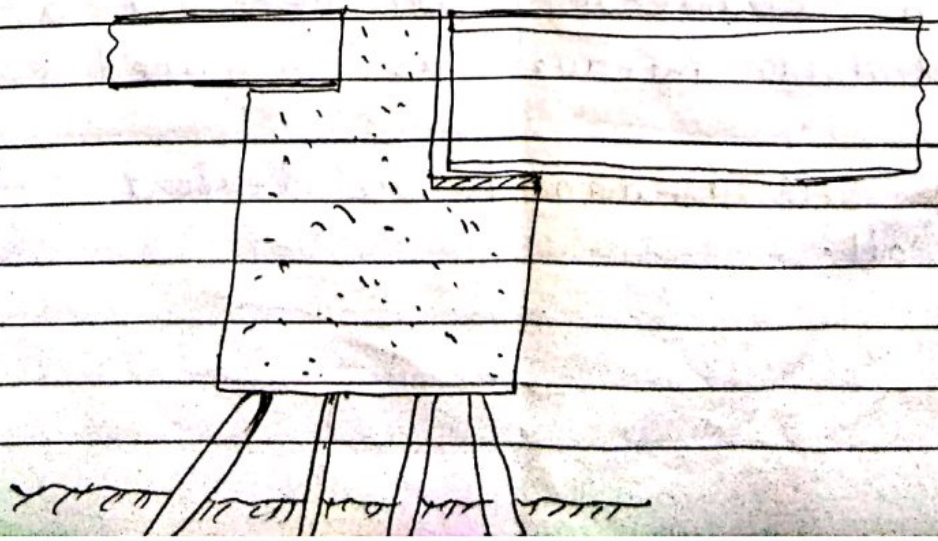
Gravity abutments are these abutments which resist the earth pressure due to its own weight. Therefore, they are ~~called~~ ~~made to~~ massive structure made of mass concrete or stone masonary.



Cross-section of Gravity Abutment

② Stub Abutment :-

Stub abutments are relatively of short height made on the embankment or slope. This type of abutment supported on piles & these piles embeded into embankment.



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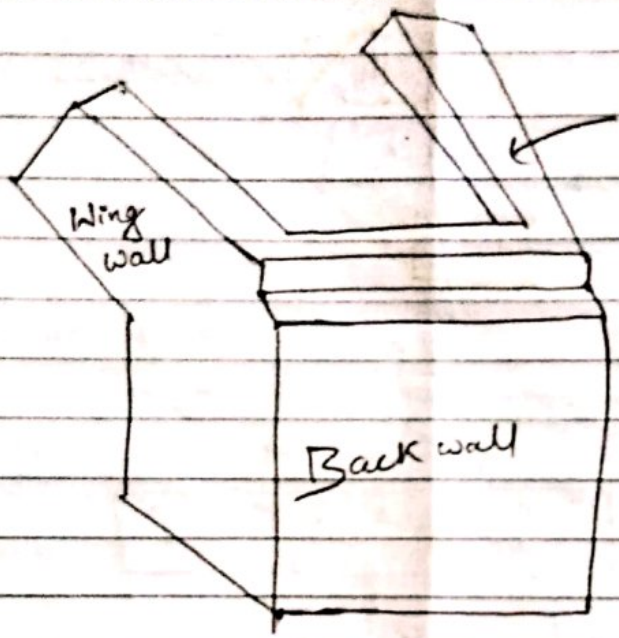
(iii) U - Abutment :-

When the wing walls of a gravity abutment are at right angle and cantilevered horizontally & vertically then this type of abutment is called U - abutment.



(iv) Counterfort abutment :-

This type of abutment is used when the height of abutment is much more. In this case, the breast wall of abutment is supported by inclined walls called counterfort.

The counterforts are provided at suitable interval as required.

This is similar to counterfort retaining wall.

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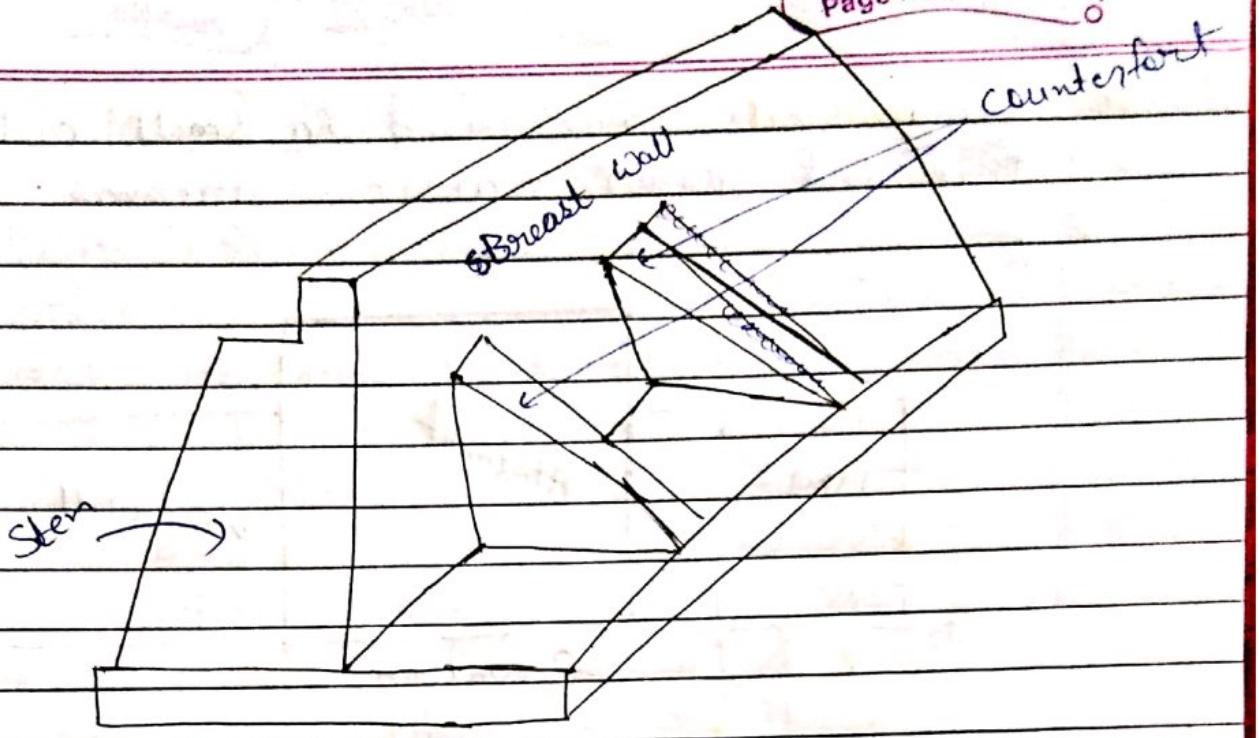

* Wing Wall :-

Wing Walls are the walls constructed at both ends of abutment to retain the earth of river bank or of approach road.

They increase the stability of abutments. The materials of construction of wing walls are the same as those abutment.

Generally abutment & wing wall are made monolithically.

* Types of Wing Walls :-

* ① Straight Wing Walls :-

This type of wing walls are made parallel to abutments on both sides.

i.e. The abutment is extended on both ends with shorter height. This type of

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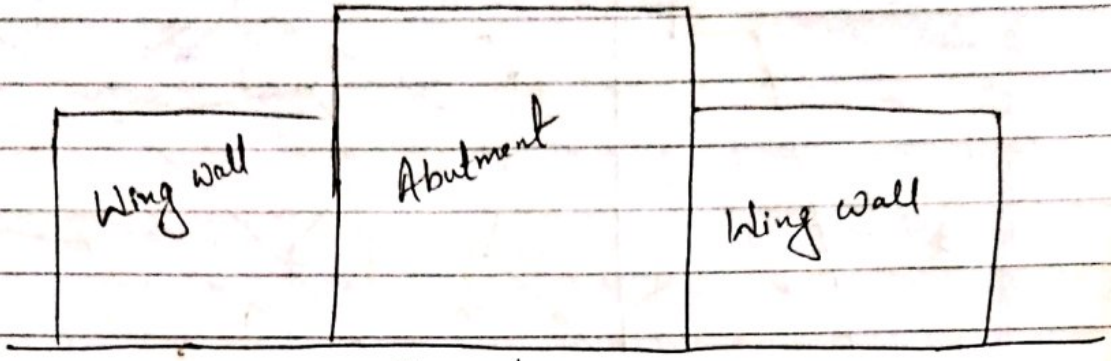
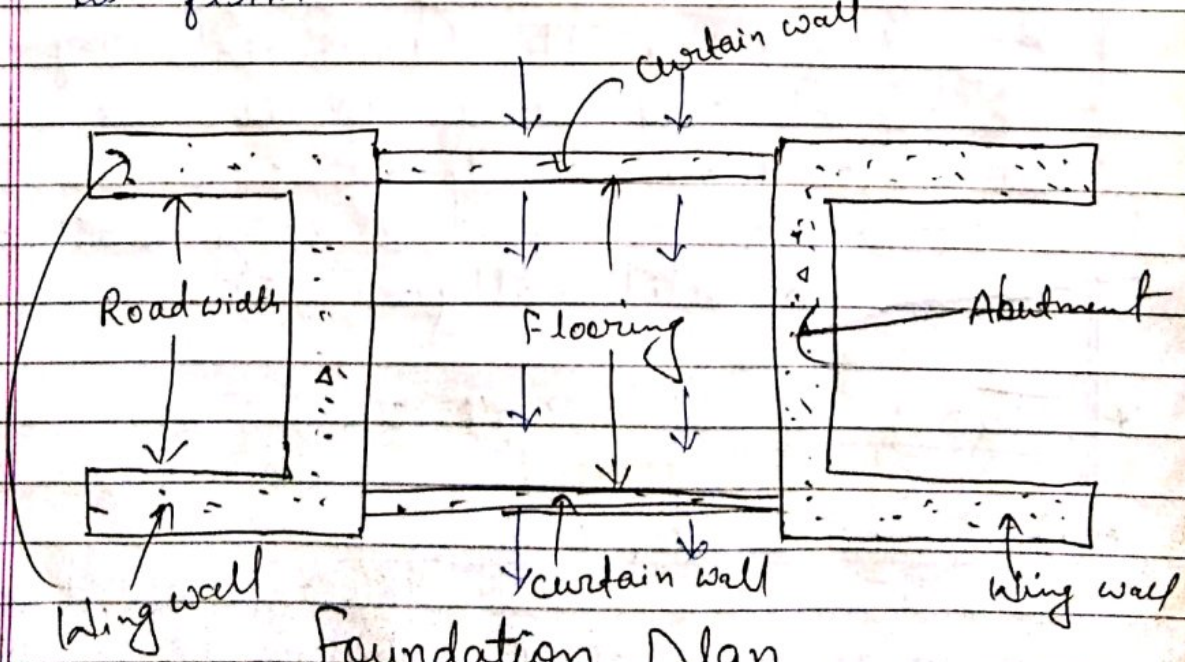
Wing Walls are used in small culverts provided over narrow streams.



Elevation.

2. Return type wing walls:- These are those wing walls which are made at right angle to abutment at both ends. These wing walls are suitable when embankments is high and riverbank is firm.



Foundation Plan

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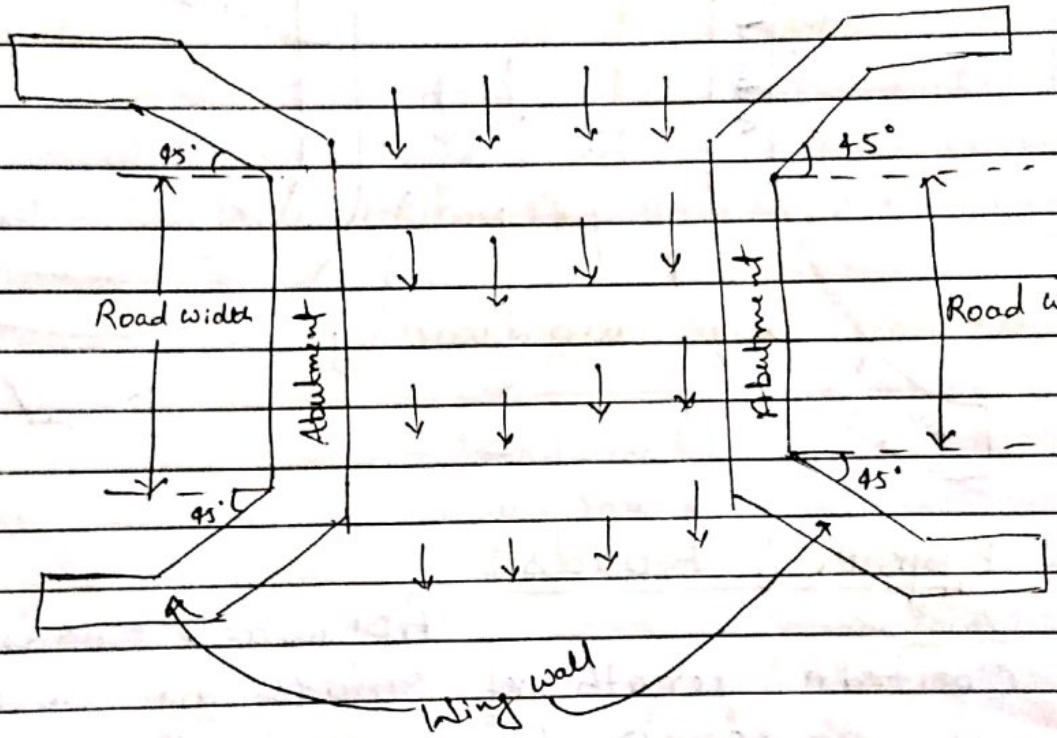
3. Splayed Wing Wall :- These are those wing walls which are made at an angle other than 90° from abutment. They are generally made at 45° to abutment.



→ This type of wing walls are used when road width is required to decrease at bridge. This type of wing wall is the best suited to small as well as big bridges.

4. Curved Wing Walls :- This type of wing wall is used in canals for smooth entry of water.

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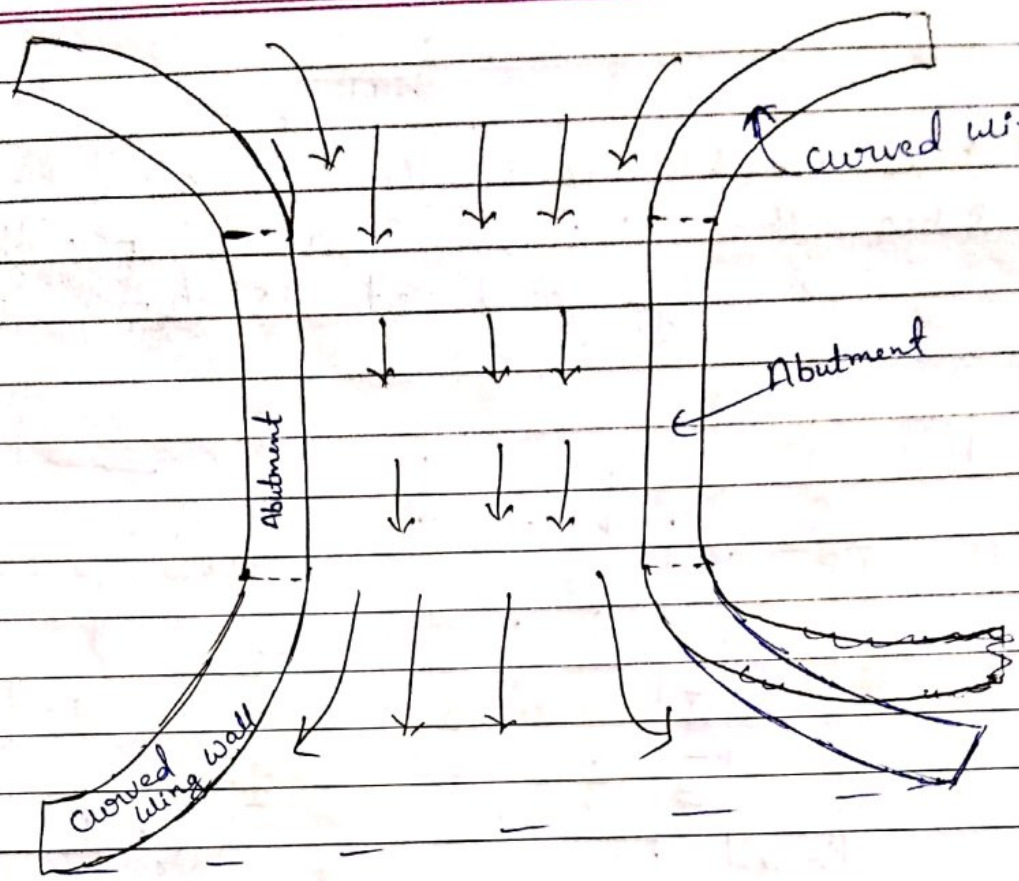

* Approach roads :-

Approach Roads are certain length of roads on both ends of bridge which connects the roadway and bridge.

On either side of bridge, approach roads should be straight at least up to 15 m as recomended by I.R.C. (Indian Road congress).

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After Holi

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☆ Temporary Bridge :-

* Causeway :-

Causeway is a pucca submersible bridge which allows flood water to pass over it.

→ It is provided on less important routes in order to reduce the cost of construction of cross drainage works.

Causeway

- Flush causeway or metal dips
- Low level Causeway or Irish bridge
- High level causeway or submergible bridge.

(i) Flush causeway or metal dips :-

Here only pavement is done is stream bed and stream water follows continuously over the firmly paved bed throughout the year.

→ To guard against scour and to protect the flooring dwarf walls are provided on both stream and downstream side. The depth of dwarf walls are 60 cm to 70 cm on upstream side and 120 cm to 150 cm on downstream.

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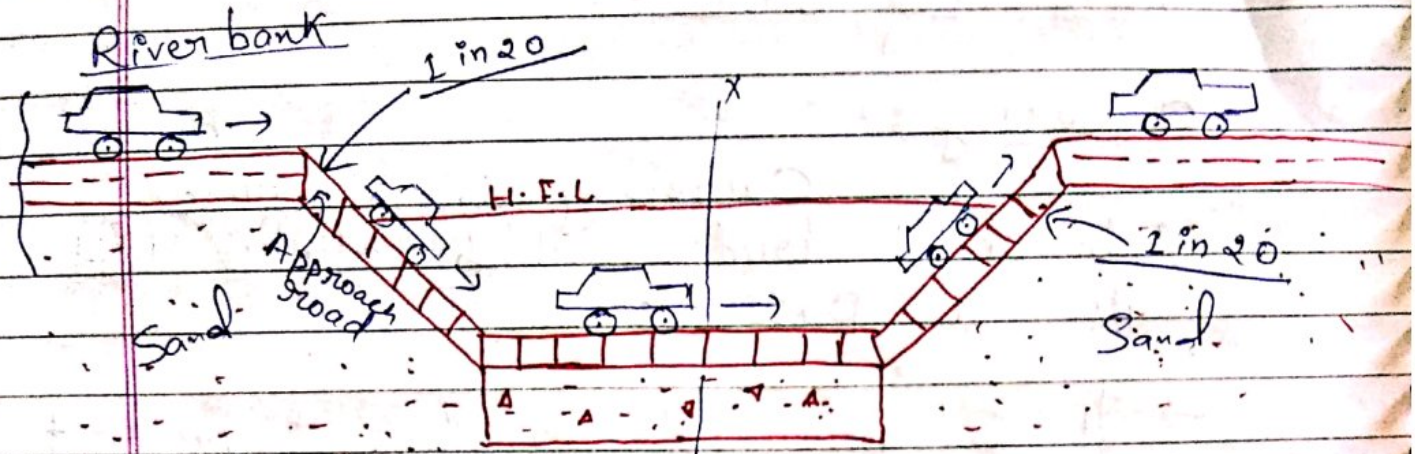

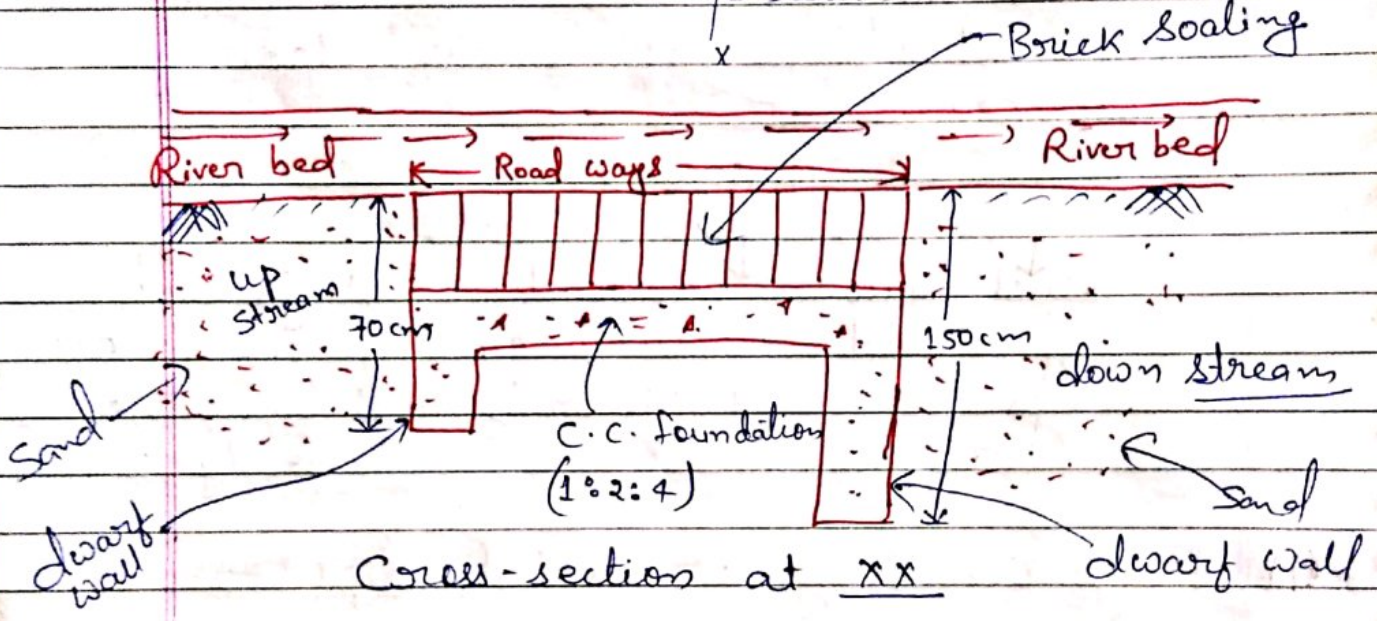

Cross-section at XX

* Suitability of causeway :-

~~It is~~ These are suitably constructed in hilly area where the maximum depth of flood water is 1.7 m and interruption does not 15 days in whole year.

(ii) Low level causeway or Iris bridge :-

In some ~~cause~~ water causes depth of water normly remains 30cm to 45 cm for most period of year and there is

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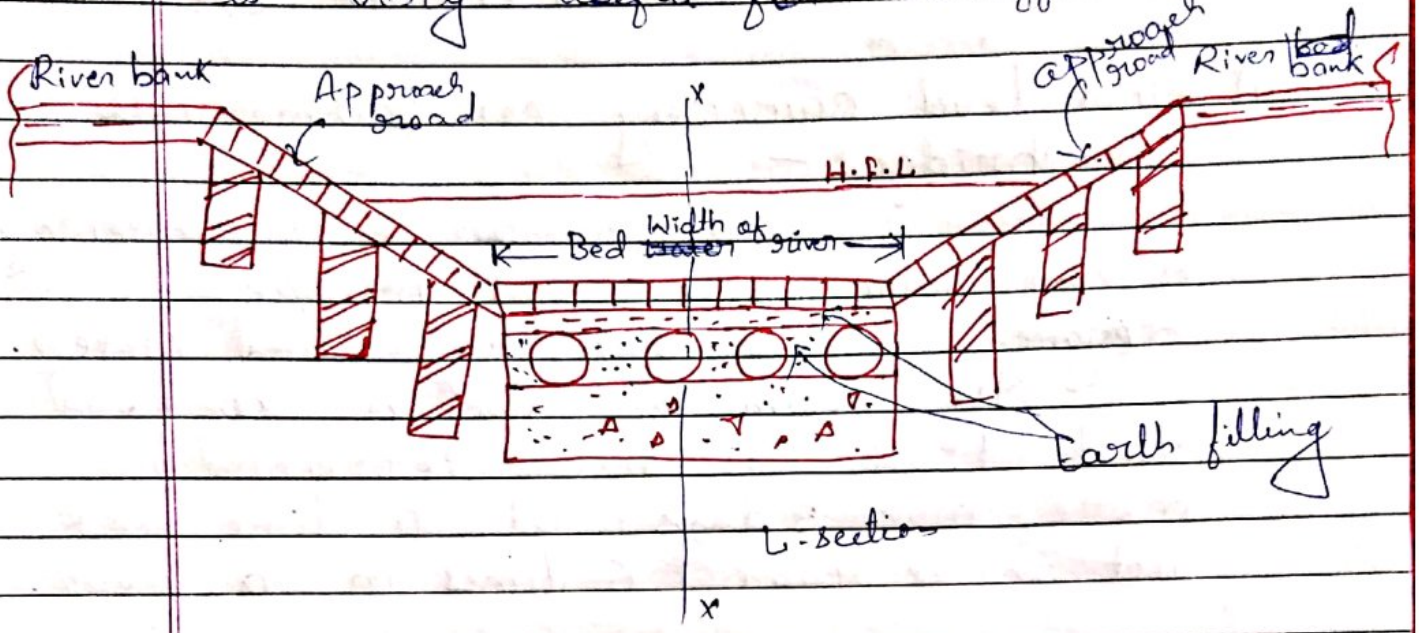
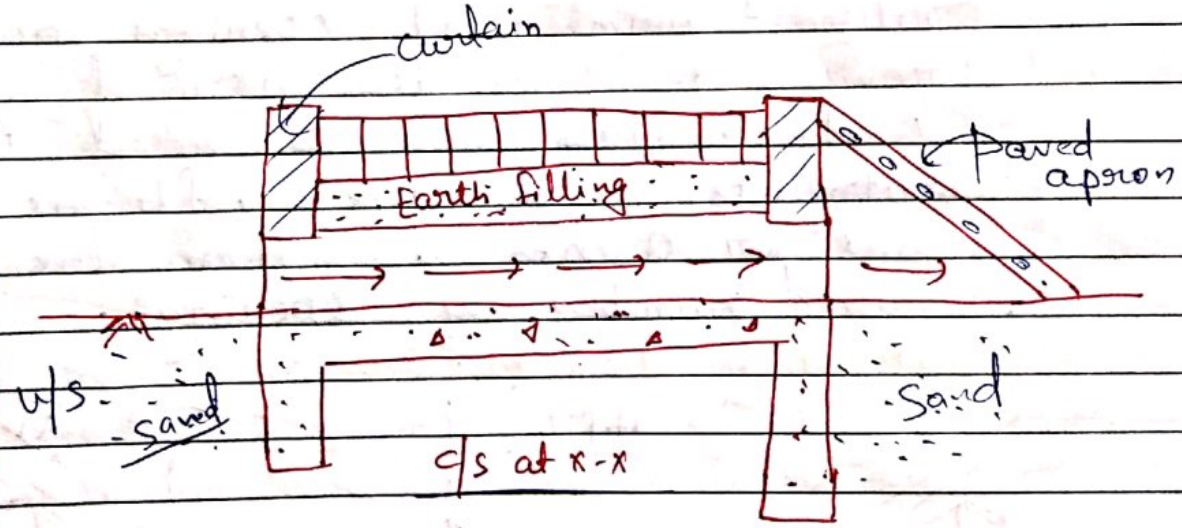
heavy discharge in rainy season. In such causes low level causeway is very useful for traffic.





→ Here the level of roadway is somewhat raised and small vents or opening are provided to pass small discharge. In case of flood, the water passes over the road and the traffic remains suspended but this situation arises only for short period in a year. Curtain walls are

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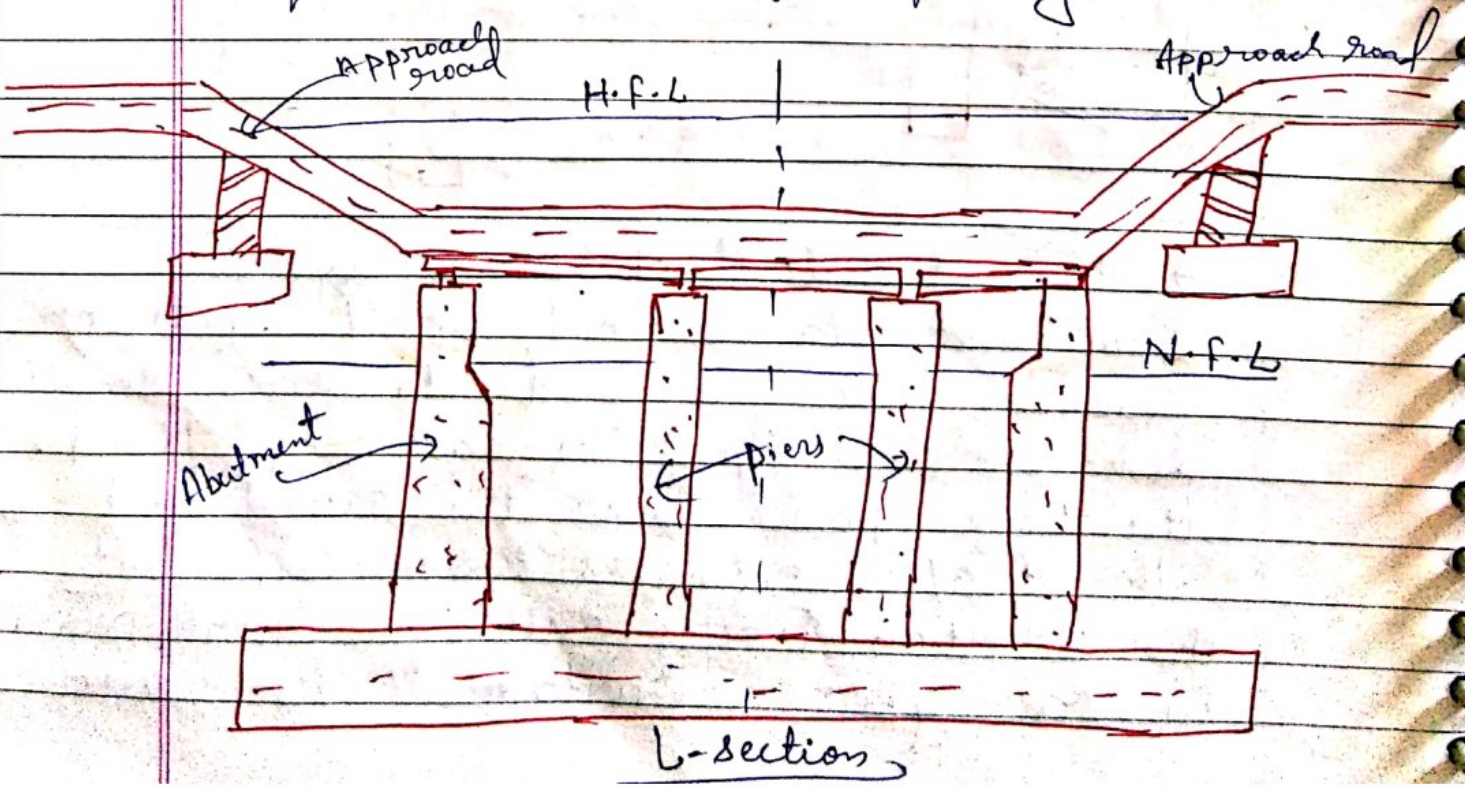
provided in both ways as shown in figure. An apron is provided to ~~both~~ check the scour in D/s side.

(iii) High level causeway or Submersible bridge :-

A high level causeway is a submersible road bridge designed to overtop the flood water. Its formation level is so fixed that traffic is not interrupted more than 3 days at a time and not more than 6 times in a year.

Sufficient number of openings are provided to pass the normal flood water. They are provided with abutments and piers, floors & beams or arches to form the required number of openings.



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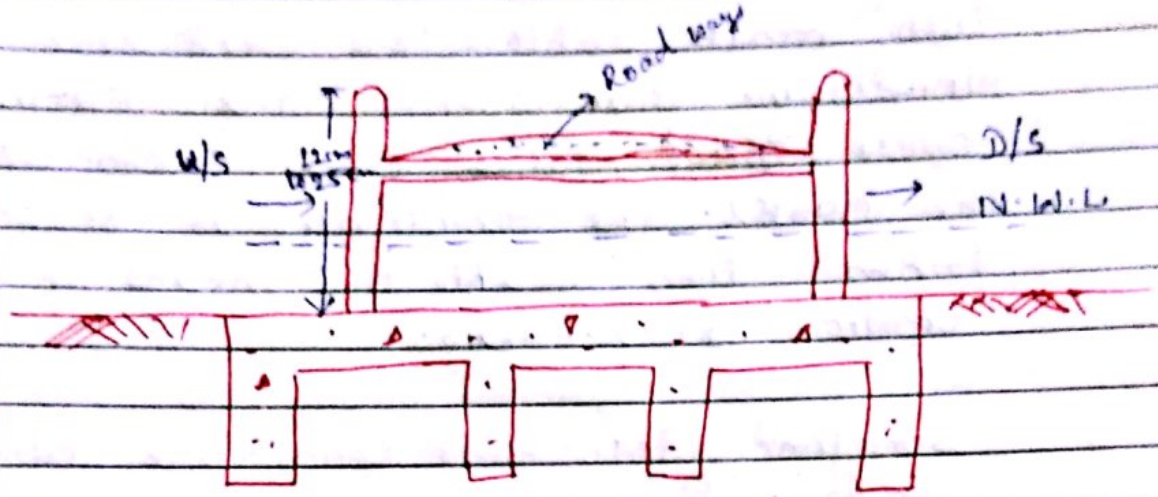
These causeways are generally 12cm to 35cm higher than local stream bed



C/S

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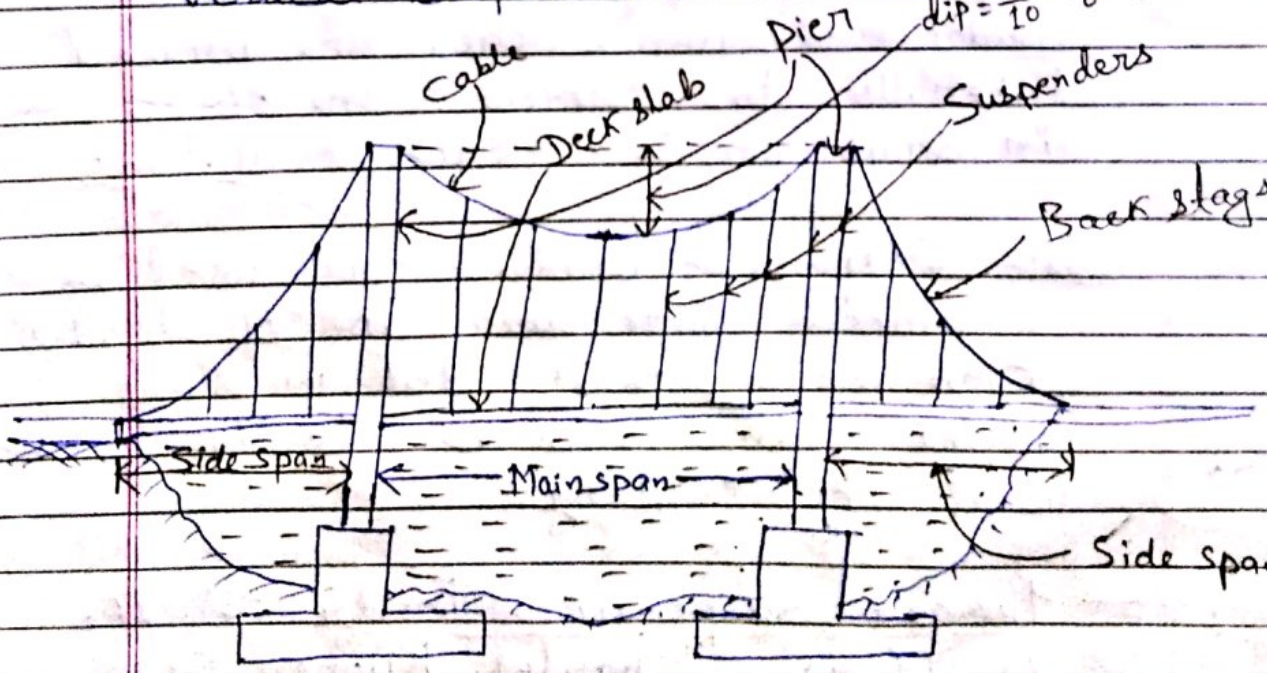
* Suspension bridge :-

Suspension bridge is a type of bridge in which the deck is hung below the suspension cables on vertical suspenders.



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★ Construction details :-

Generally suspension bridges are of single span. There are two main cables on each side of roadway. These cables are carried over solid piers and anchored to the banks. The roadway is suspended from two cable by means of vertical suspenders.

Sometimes two side spans are also added. These side spans are suspended from back stays by means of vertical suspenders.

$$\frac{\text{Side span}}{\text{Main Span}} = 0.17 \text{ to } 0.50$$

Suspension bridge is not rigid bridge and hence they are braced laterally to prevent the change in shape or to reduce oscillation.

Uses:- Suspension bridges are used in placed where other type of bridge can not be constructed in short time. These type of bridge are used by Military.

→ Largest Suspension bridge in the world is "Charles Kuonen Suspension bridge" in Switzerland which is 1621 feet = 494 m long.

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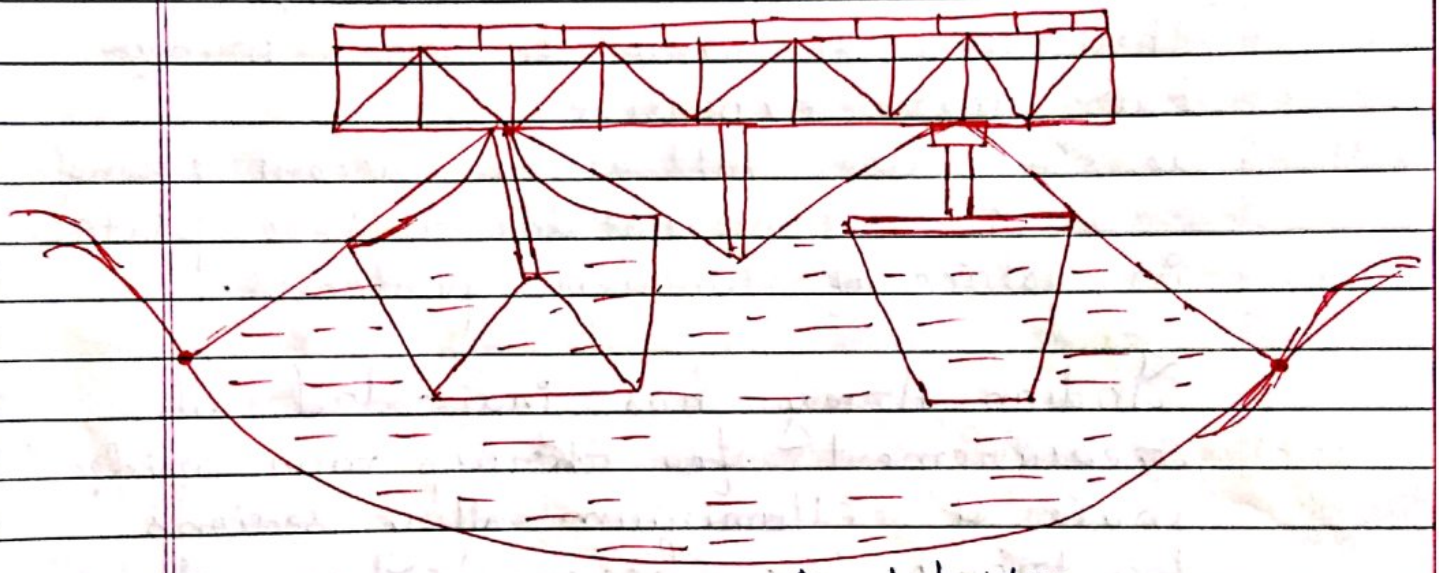
* Floating bridge :-

The bridge which floats on water surface is called floating bridge.

In this category of bridge, superstructure is supported on floating boats or pontoons or rafts.



Boat bridge

(a) Boat bridge :-

This bridge is supported on floating boats and its superstructure consists of trussed beam called "gun wale" and transverse planks over them.

The boats are hold in position by anchors on both upstream and downstream side. The boats are further stiffered along the bridge.

In order to take care of rise and

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fall of water level special attention should be paid to the connections at both banks.

The advantage of this type of bridge in its portability and rapidity in construction.

(b) Pontoon bridge :-

This bridge is similar in construction to boat bridge. They are superior to boat bridge but more expensive.

~~is to use inftoad~~ The recent trend is to use infloatable rubber pontoon in place of wooden pontoons.

Indian Army has indicated its requirement for "Krupp man bridge" made of alluminium alloy sections for transporting heavy fighting vehicles across the rivers.

Accordingly, the facilities of their manufacturing has been set up at ordinance factory in Ambajhari in Maharastra and the production of "Krupp man Bridge" has already started.

(c) Raft Bridge :- The superstructure of raft bridge is similar to that of float bridge.

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The Sub-structure consist of floating piers made caskes or barrels lashed together in lines 6 or 7 in number at top across the span.

These barrels acts as "gun wale" in boat bridge which support the road.

(d) Timber bridge :-

Timber bridge is regarded as a temporary bridge which is constructed in certain situations and locations. It is generally used as foot bridge or ~~fly over~~. over bridge connecting two plateforms. Crenerally timber bridge is a road bridge.

Timber bridges are not papular now a days because of following disadvantages :-

(i) The life of timber bridge is short because it gets deteriorated when exposed to weathering agencies like Sun, Wind, rain, Snowfall, etc.

(ii) Timber is easily liable to fire.

(iii) Timber can not be used for large span.

(iv) The Strength of timber is not uniform in all directions.

(v) Timbers are required to arrange so that

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Stresses do not occur along the weaker section.

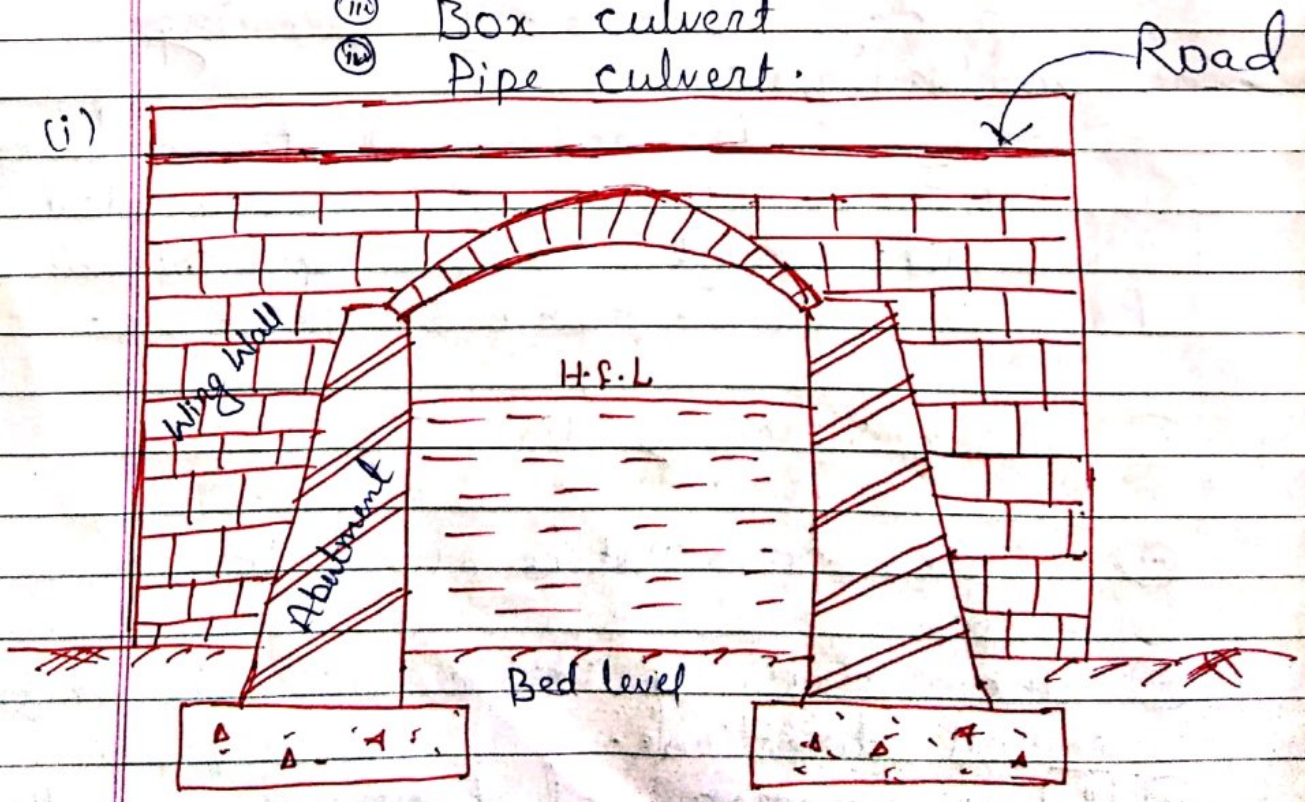
(vi) Factor of Safety of timber bridge is taken as 4 to 5.

✱ Permanent bridge :-

* Culverts :- Culverts is a small bridge whose span is less than or equal to 6m. Culverts are permanent drainage structure constructed to carry a roadway or railway track over a small stream or nad or nalla.

* Culverts are of following 4 types :-
  (i) Arch Culvert
  (ii) Slab culvert
  (iii) Box culvert
  (iv) Pipe culvert.

(i)



Arch culvert

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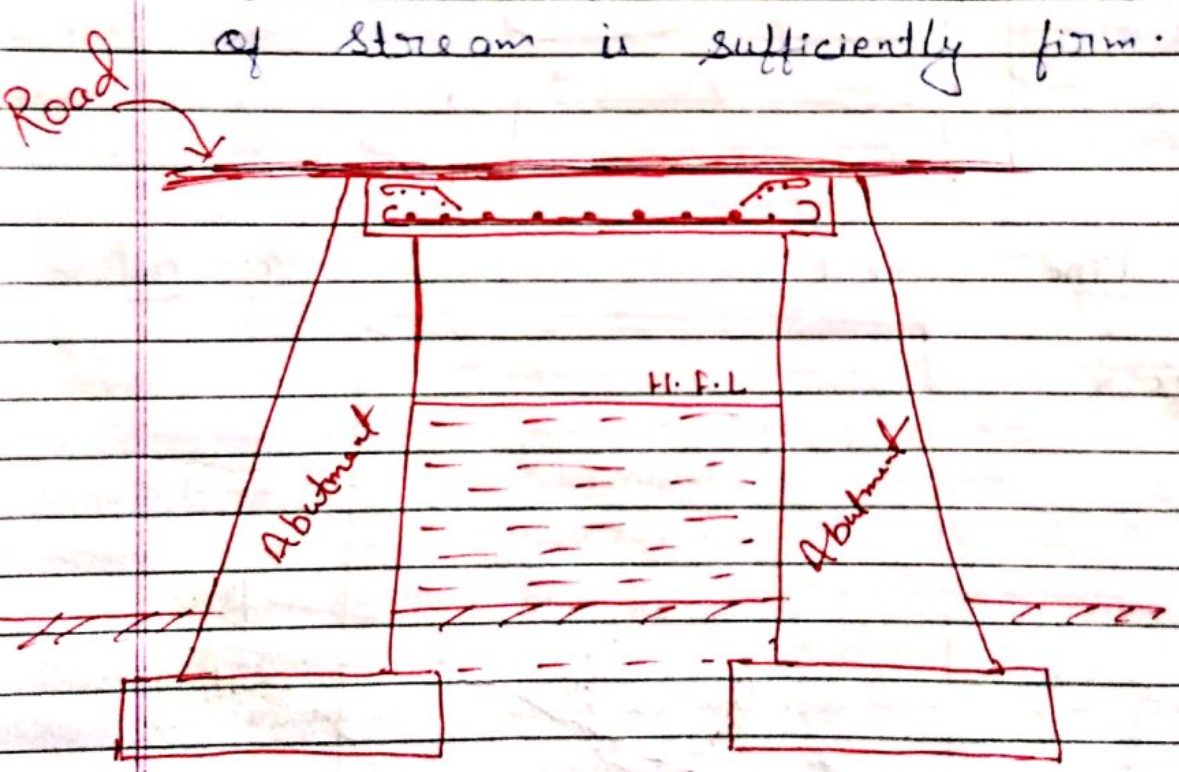
① Arch culverts :- It is the culvert where superstructure consists of one or two arches. It may be made masonry or concrete.

(ii) Slab culvert :-

In this type of culvert an R.C.C slab is simply supported on abutments. These culverts are provided for max^m span of 3m and are suitable where the bed of stream is sufficiently firm.



(iii) Box culvert :-

Box culvert consists of one or two R.C.C box of square or rectangular openings with span restricted to 4m.

Box culverts are suitable if the bearing capacity of soil is low

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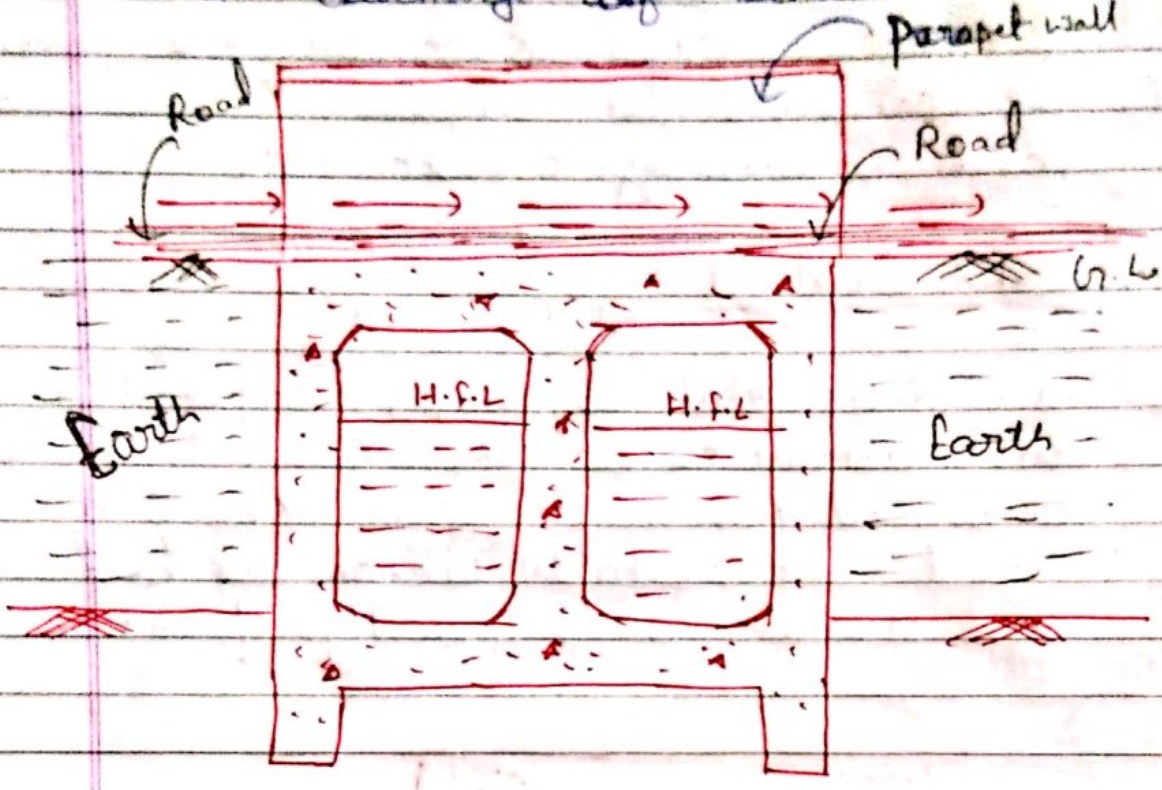
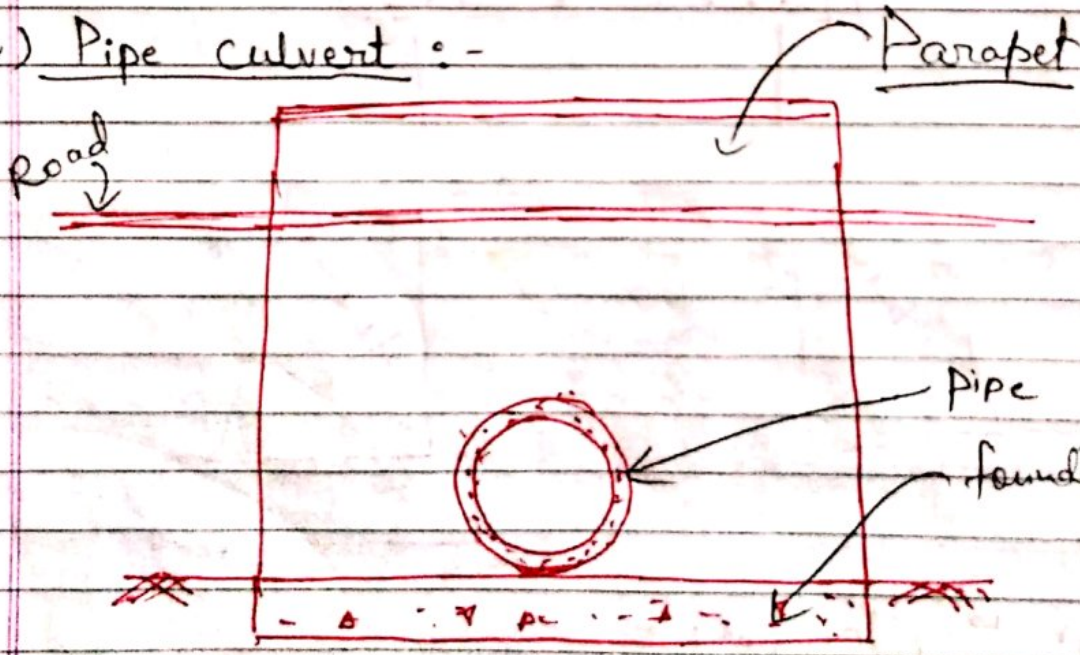
and discharge of stream is small.



(iv) Pipe culvert :-



A pipe culvert consist of a pipe barrel under the embankment with protection work at entry and exit.

Pipe culvert is used when channel is not well defined and discharge in limited.

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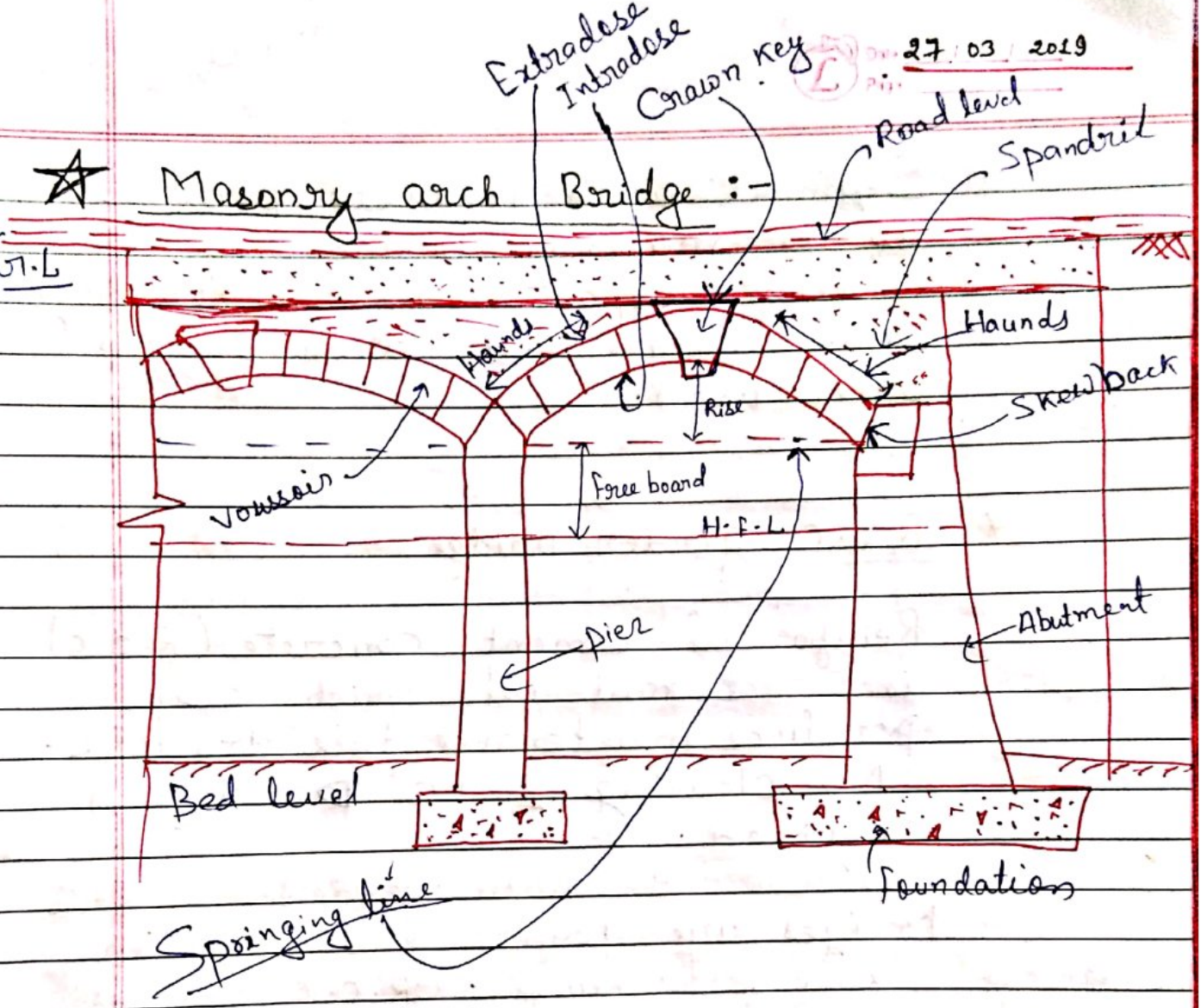
★ Masonry arch Bridge :-



* Masonry arch Bridge :-

Masonry arch bridge are very commonly used as road bridges of moderate span. Their simplicity in construction & pleasing appearance make them suitable for road bridges.

The masonry arch bridges may be made of either stone masonry or brick masonry. The common type of arch shapes are segment, semi-circular, elliptical, parabolic, pointed & multicentred.

Lakshya

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Segment arch is more popular as a masonry bridge for medium span length. For long span multicentred arch bridges are used.

* R.C.C girder bridge :-

Reinforced cement concrete (R.C.C) is that material which can produce maintenance free structure. No cleaning & no painting is required.

After independence R.C.C bridges are preferred to earlier massive structure. R.C.C bridges are made with simply supported T-beam-Slab arrangement for a span up to 30m. For long span up to 60 m cantilever with suspended span with hollow box-girder & slab arrangement is preferred.

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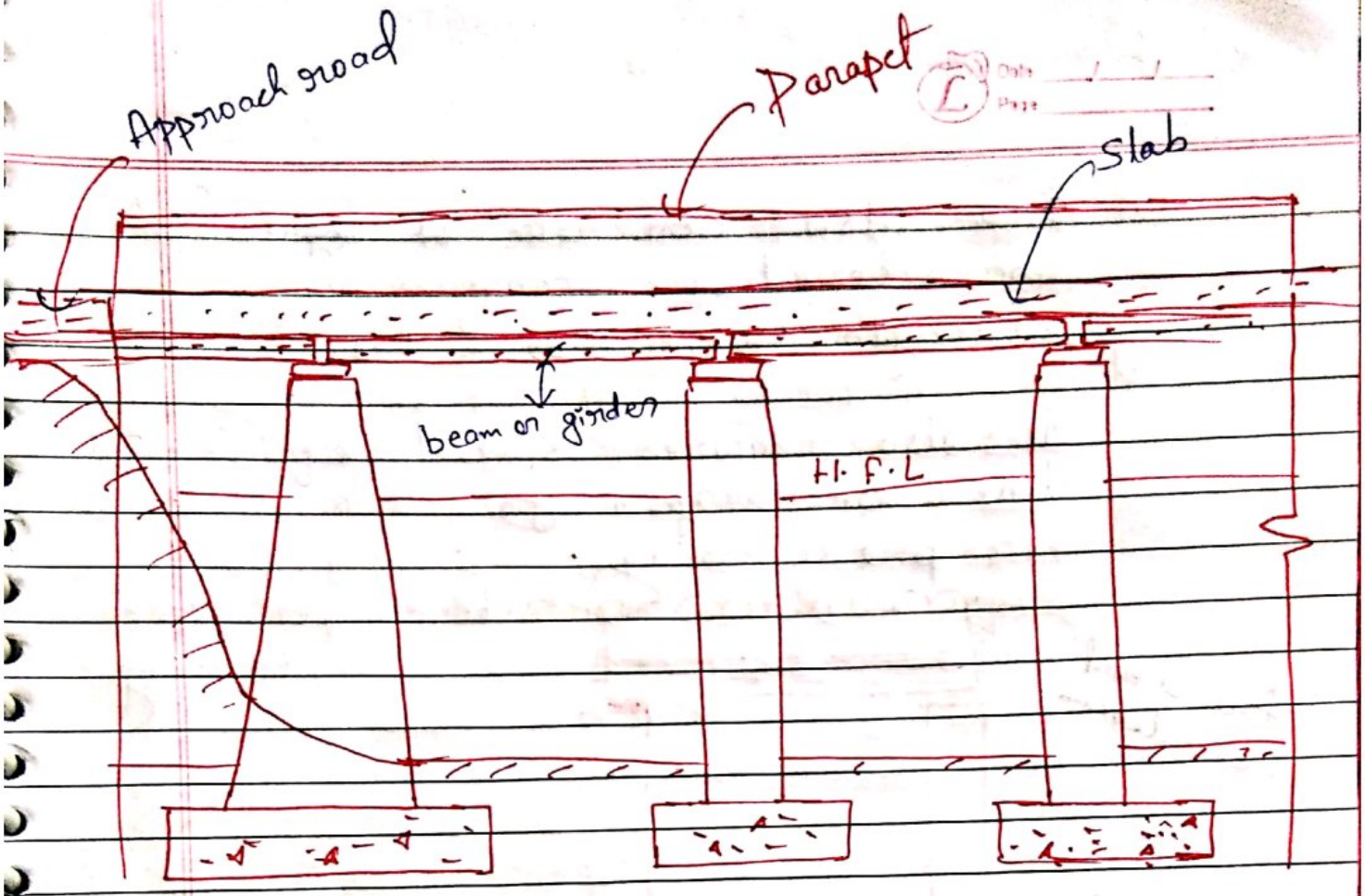

* Prestressed Concrete bridge :-

The principle of prestressed concrete is that section in subjected to compressive stresses prior to loading so that even lighter (thinner) section can able to carry greater load.

The main advantage of prestressed concrete bridge is that the higher load carrying capacity with fewer expansion joints.
The section under prior compressive stress eliminates the cracking under service load. However, prestressed concrete construction requires steel of high tensile strength (Fe500 & above)

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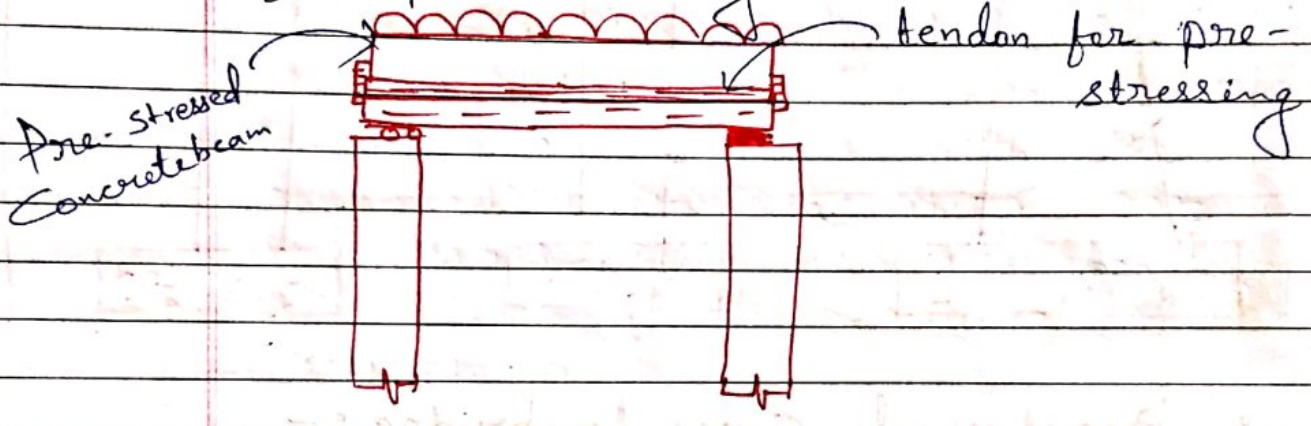
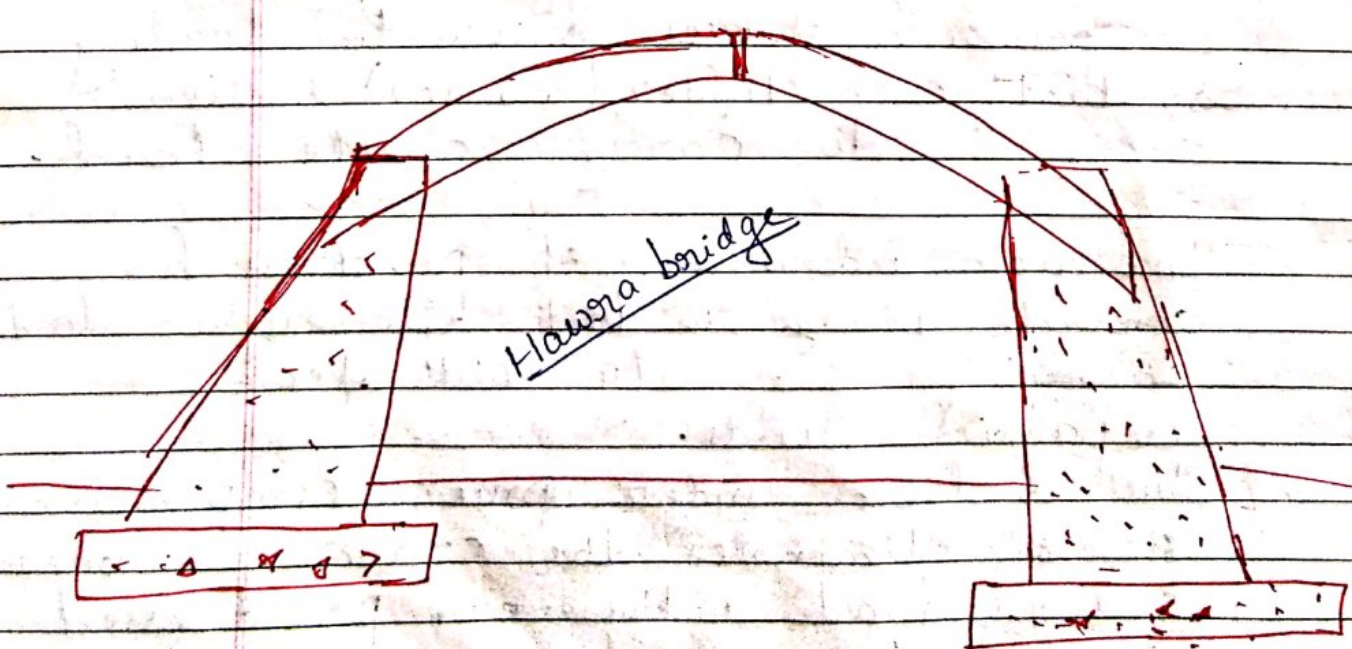
and also concrete of ~~high~~ higher characteristics compressive strength above M35 & M40.

It also requires special equipments like anchorage, ~~D~~ Jack etc. for pre stressing.



* Cantilever bridge :-



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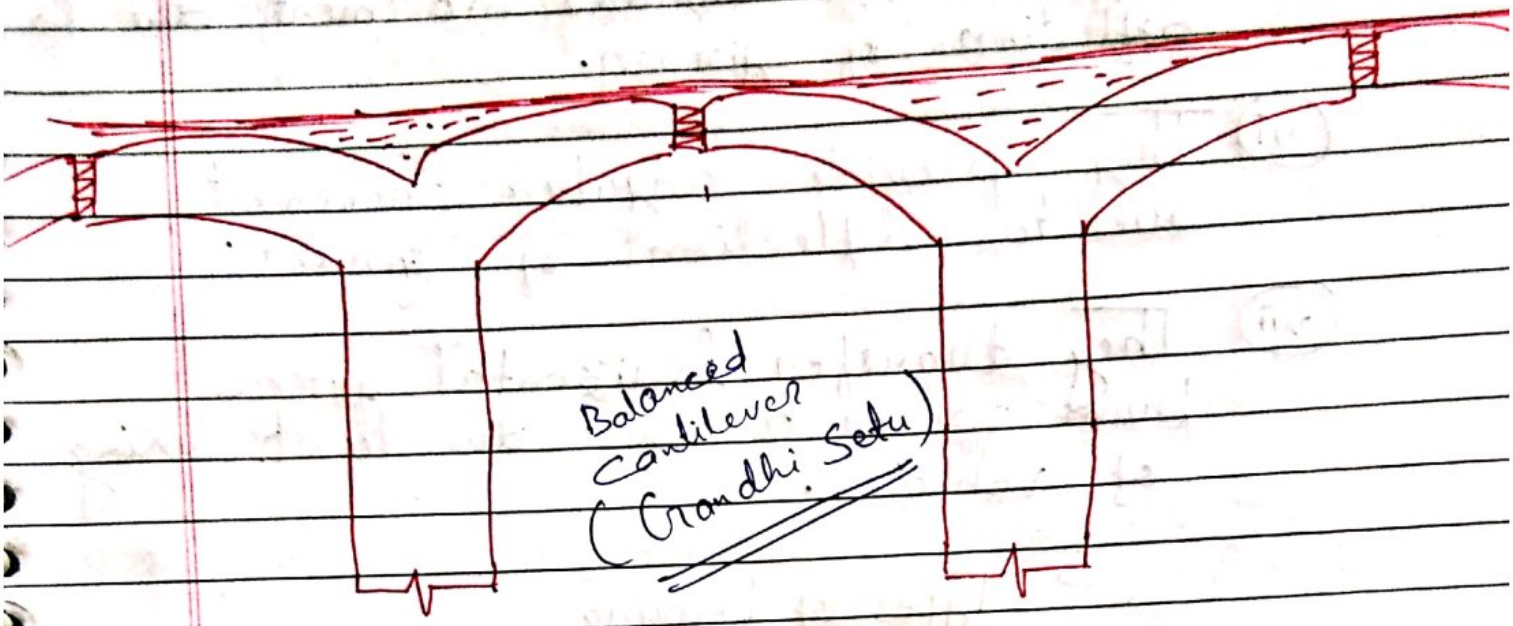

28.03.19

☆ **Bridge Bearing :-** The device which are provided at the top of piers & abutment to allow free expansion or contraction and deflection of bridge superstructure are known as bridge bearings.

* **Functions of bridge bearing :-**

(i) To distribute the load on larger area.

(ii) They allow the free angular movement at the end of girder of bridge.

(iii) They provide free linear movement of girder.

(iv) They allow thermal expansion or contraction of girder.

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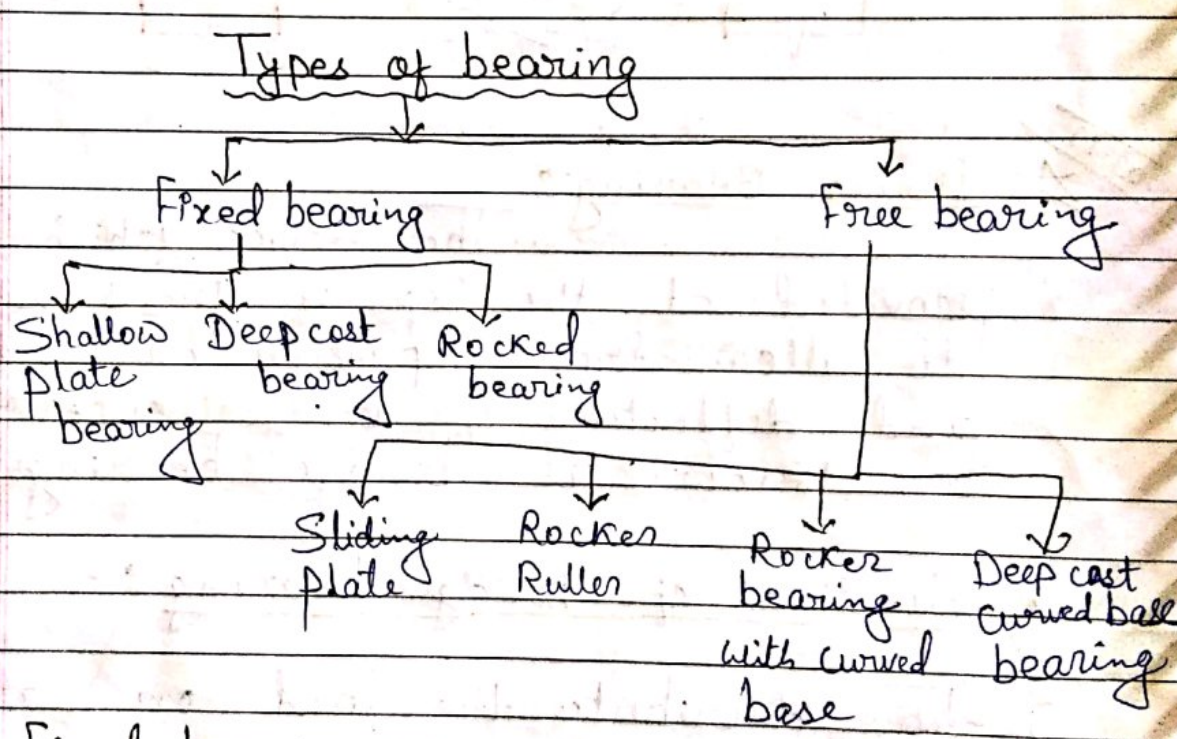
(v) They provide angular movement due to deflection of girder.

(vi) They provide angular movement due to deflection of girder.

(vii) They transfer horizontal force from girder to pier due to breaking of vehicles.



① Fixed bearing :-

(i) Shallow bearing or Fixed plate bearing :-

It is the simplest type of fixed end bearing which consist of a thick steel plate which is bolted or anchored to the top of abutment. Over the abutment Iron girder end is rigidly fixed.

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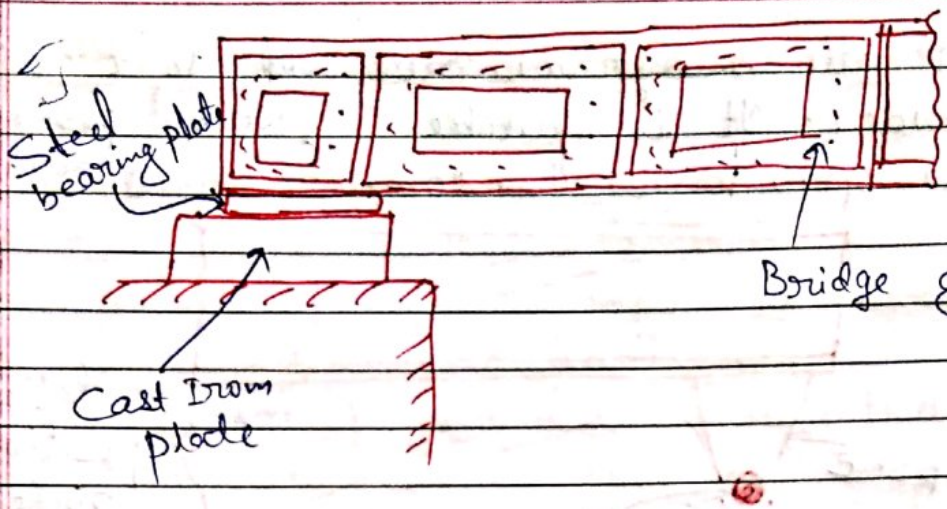
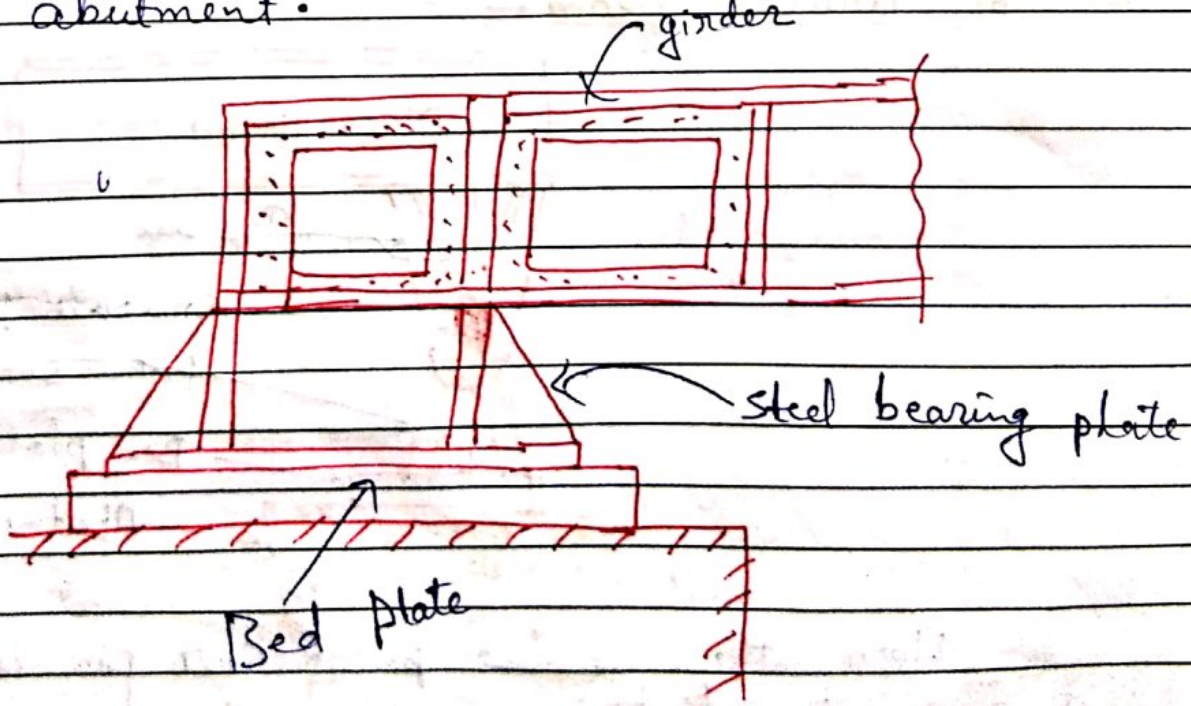


(ii) Deep cast base plate bearing :-

This is improvement over shallow plate bearing can be used for span 12m to 20m. It can be distribute the load more uniformly over the abutment.



(iii) (a) Rocker bearing : When the girder tends to deflect due to rolling load, the top shoe rotate over the pin. Hence,

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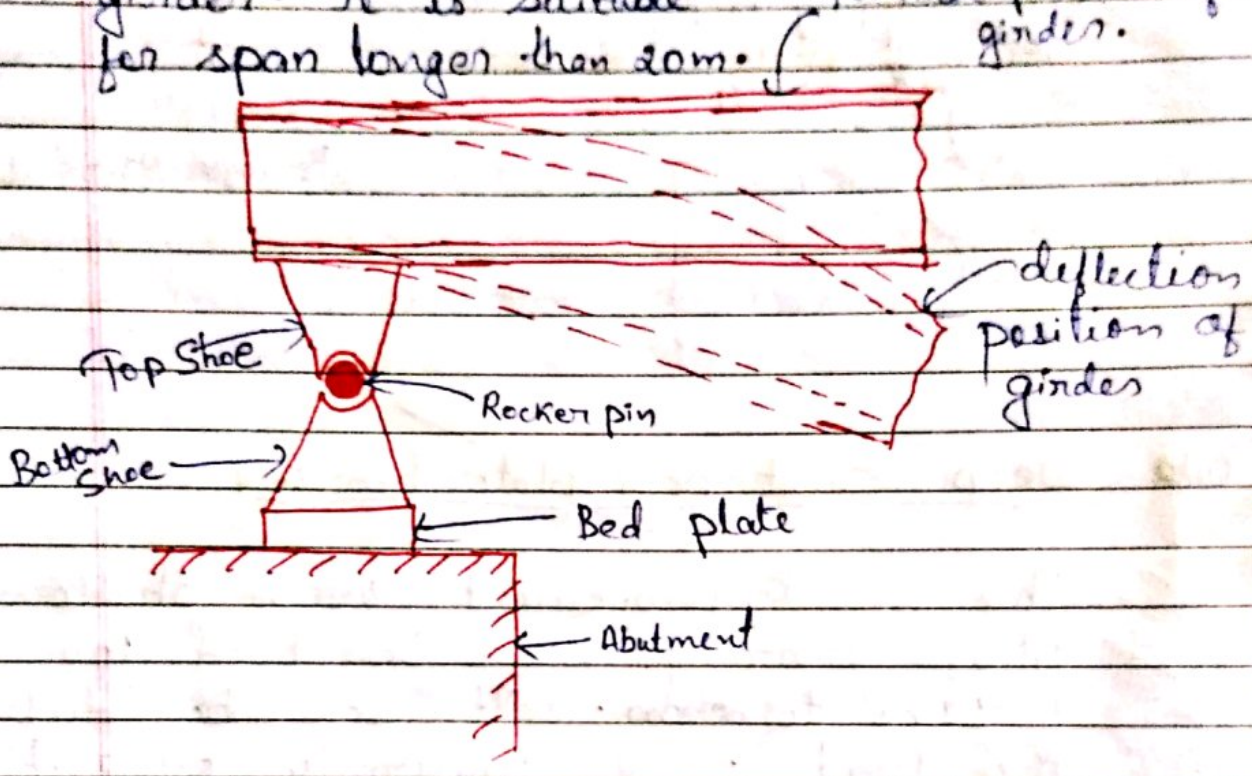
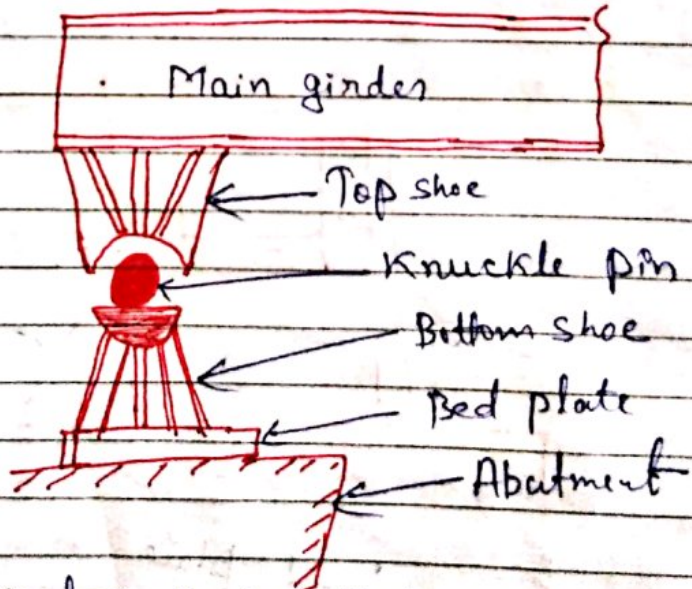
it allows angular movement to the girder. It is suitable for span longer than 20m.



(iii) (b) Knuckle beam :-



Here the ~~girder~~ rocker pin is replaced by a knuckle pin which is attached to the bottom shoe. This type of bearing allow only angular movement.

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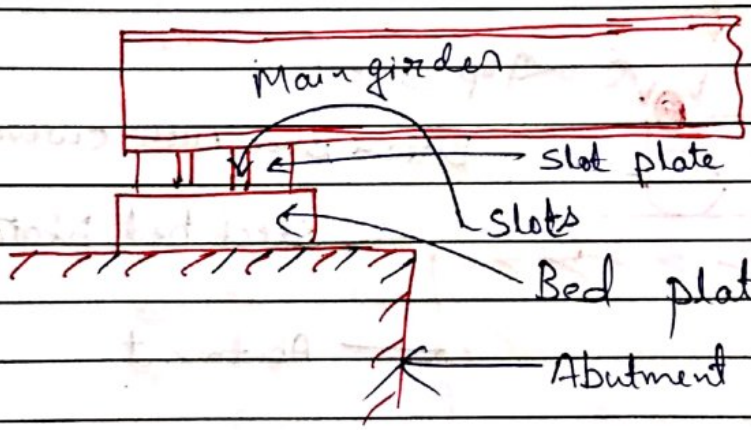
2. Free bearing or Expansion bearing

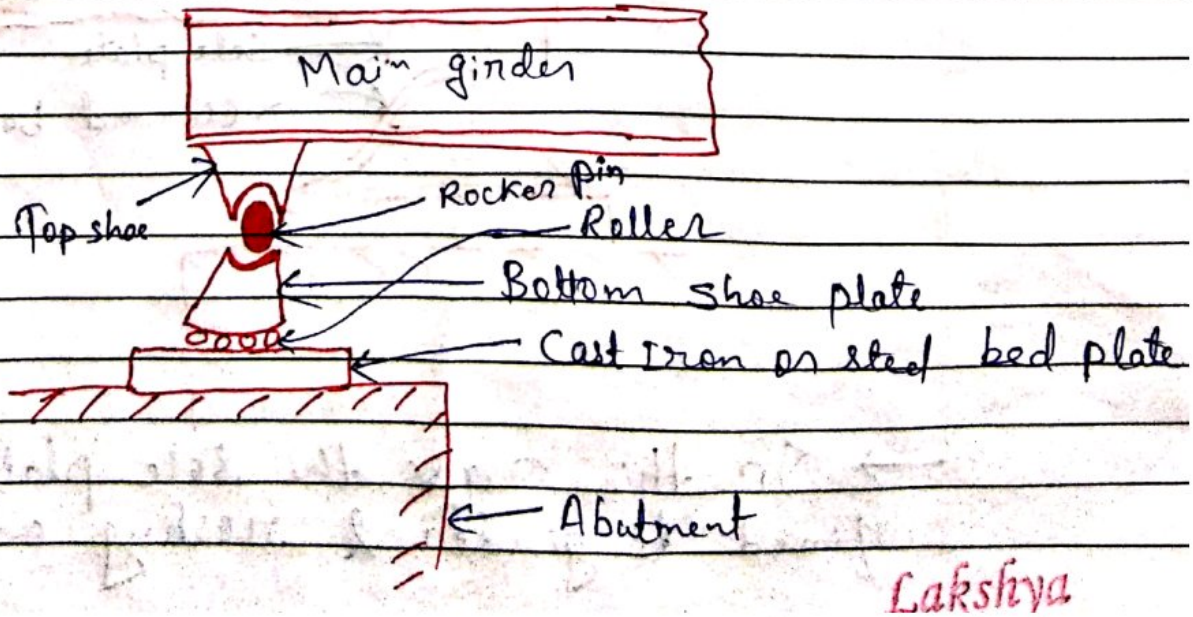
(i) Sliding plate bearing :-

This is simplest type of free bearing. It consists of sole plate anchored to bed plate. Slots are provided for longitudinal movement of girder. Bed plate is anchored to the abutment.



(ii) Rocker Roller bearing :-

This type of bearing allows both longitudinal movement as well as angular movement.



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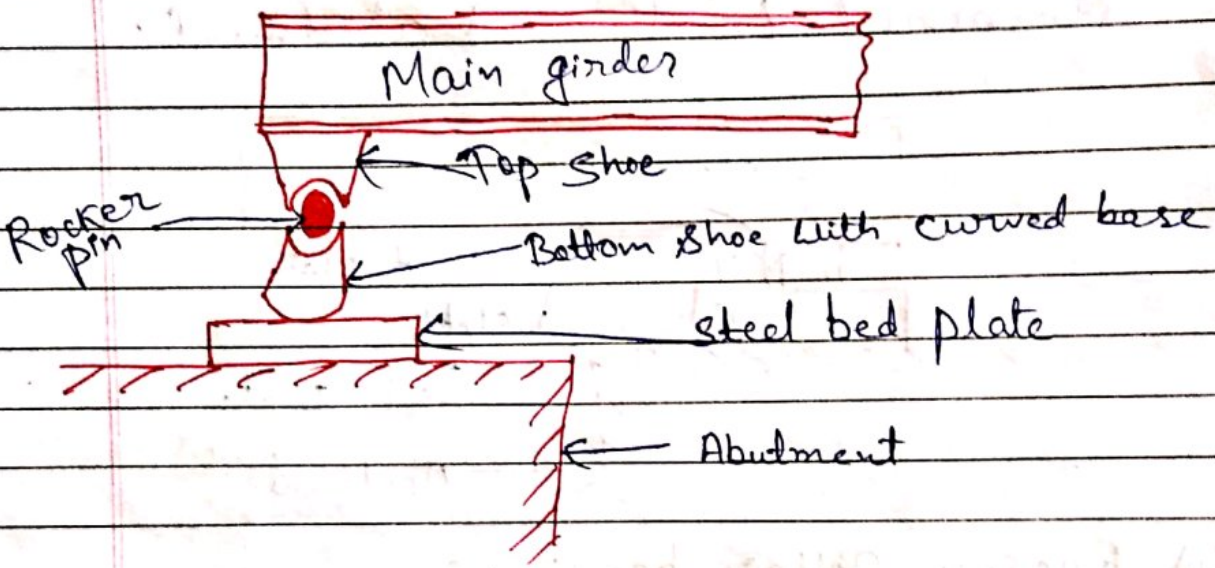
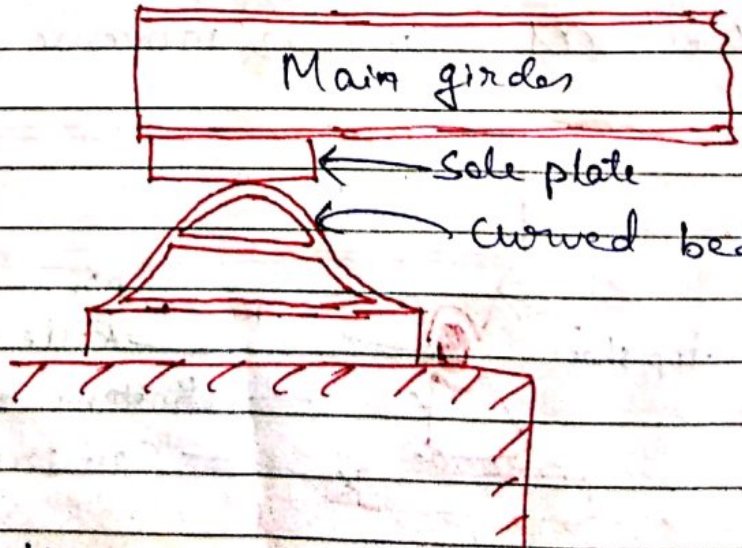
(iii) Rocker bearing with curved base :-

When span is of short length then rollers head not require but the base of bottom shoe is made curved. The curved base serves the same purpose as rollers.



(iv) Deep cast base with curved plate bearing :-



→ In this case the sole plate is fixed to girder & resting on curved

bed plate which is fixed on masonary abutment. This bearing is very useful where only angular movement occurs. This is used for span length ranging from 12 m to 20m.

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