

Cross Drainage Works:

A "cross drainage work" is a hydraulic structure which needs to be constructed at the crossing of a natural stream and an irrigation canal flowing normally at right angles underneath or over the natural stream.

It is generally a very costly item and should be avoided by,

- i. Diverting one stream into another.
- ii. Changing the alignment of the canal so that it crosses below the junction of two streams.

Necessity of Cross- Drainage Works:

The following factors justify the necessity of cross drainage works,

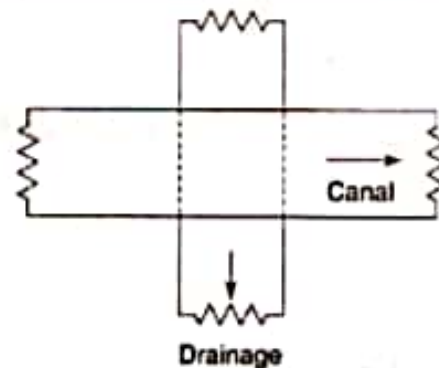
1. The water shed canals do not cross natural drainages. But in actual orientation of the canal network, this ideal condition may not be available and the obstacles like natural drainages may be present across the canal. So, the cross drainage works must be provided for running the irrigation system.
2. At the crossing point, the water of the canal and the drainage get intermixed. So, for the smooth running of the canal with its design discharge the cross drainage works are required.
3. The site condition of the crossing point may be such that without any suitable structure, the water of the canal and drainage cannot be diverted to their natural directions. So, the cross drainage works must be provided to maintain their natural direction of flow.

Types Of Cross Drainage Works:

Depending upon the relative bed levels, maximum water levels and relative discharges of canals and drainages the cross drainage works may be of following types,

1. Type1-Irrigation Canal passes over the drainage:

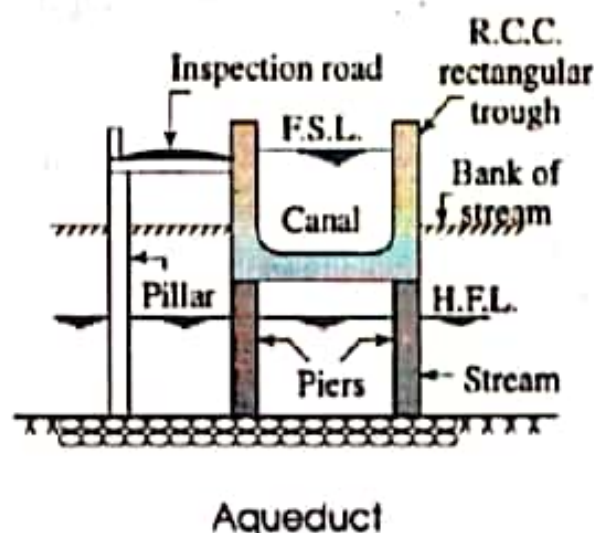
In this type of C.D work, an irrigation canal is taken over the drainage



This condition involves construction of following,

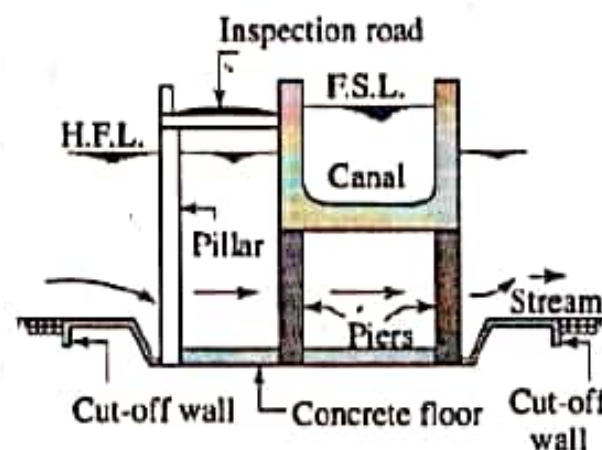
a) Aqueduct:

The hydraulic structure in which irrigation canal is passing over the drainage is known as aqueduct. This structure is suitable when bed of canal is above the highest flood level of drainage. In this case, the drainage water passes clearly below the canal.



b) **Siphon Aqueduct:**

The hydraulic structure in which irrigation canal is passing over the drainage, but the drainage water cannot pass clearly below the canal is known as siphon aqueduct. It flows under siphoned action. This structure is suitable when the bed level of canal is below the highest flood level of the drainage.



Siphon aqueduct

Advantages of Type1:

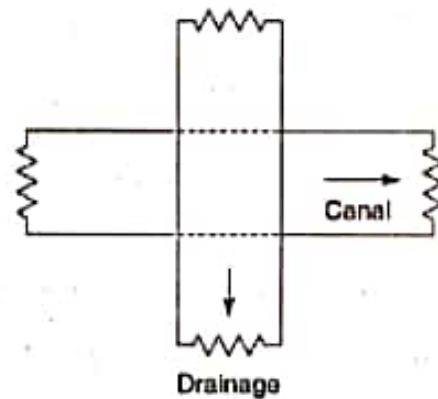
- The canal running perennially is above ground and is open to inspection.
- Damage done by floods is rare.

Disadvantages of Type1:

- During high floods, the foundation can be scoured or the water way of the drain may be choked with trees.

2. Type2-Drainage passes over the irrigation canal:

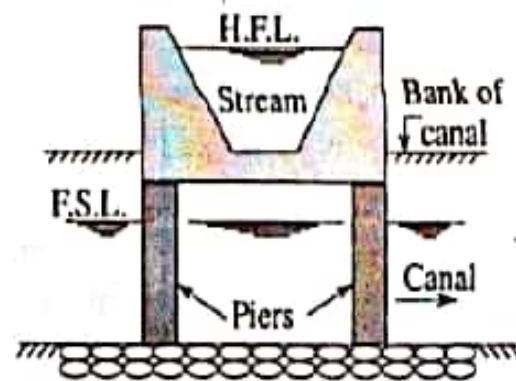
In this type of cross drainage work, drainage is taken over the canal.



This condition involves the construction of the following,

a) Super Passage:

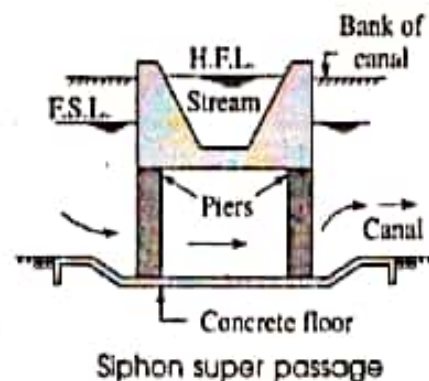
The hydraulic structure in which the drainage is passing over the irrigation canal is known as super passage. This structure is suitable when the bed level of drainage is above the flood surface level of the canal. The water of the canal passes clearly below the drainage.



Super passage

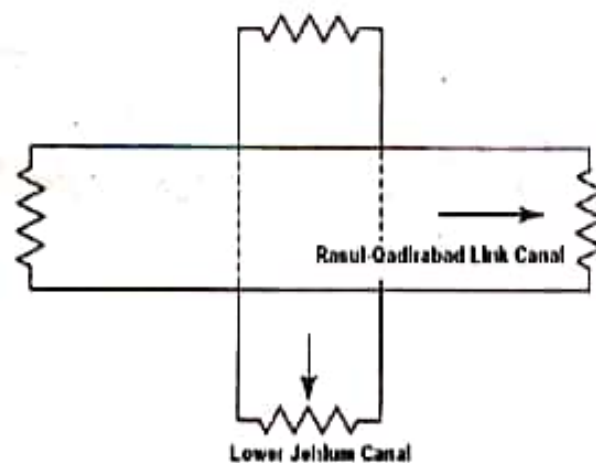
b) Siphon Super passage:

The hydraulic structure in which the drainage is taken over the irrigation canal, but the canal water passes below the drainage under siphonic action is known as siphon super passage. This structure is suitable when the bed level of drainage is below the full supply level of the canal.



c) Canal Siphon:

If two canals cross each other and one of the canals is siphoned under the other, then the hydraulic structure at crossing is called "canal siphon". For example, lower Jhelum canal is siphoned under the Rasul-Qadirabad link canal and the crossing structure is called "L.J.C siphon"



Advantages of Type2:

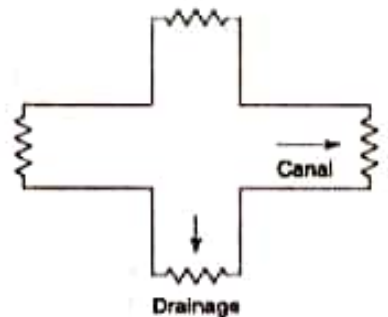
- C.D works are less liable to damage than the earthwork of canal.

Disadvantages of Type2:

- Perennial canal is not open to inspection.
- It is difficult to clear the silt deposited in the barrels of the C.D. work.

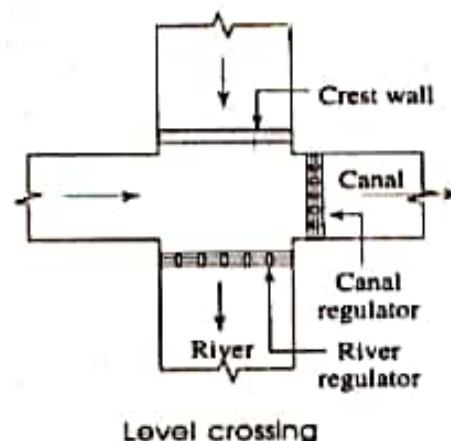
3. Type3-Drainage and Canal intersection at the same level:

In this type of work, the canal water and drainage water are permitted to intermingle.



a) Level Crossing:

When the beds of the drainage and canal are practically at the same level, then a hydraulic structure is constructed which is known as level crossing. This is suitable for the crossing of large drainage with main canal.

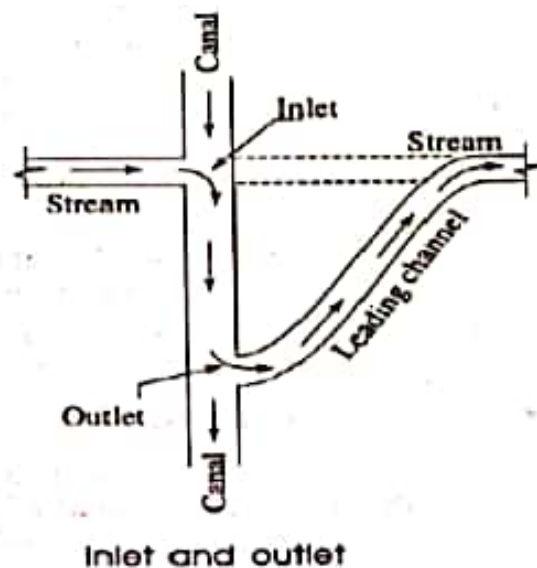


The level crossing consists of the following components.

1. **Crest Wall:** It is provided across the drainage just at the upstream side of the crossing point. The top level of the crest wall is kept at the full supply level of the canal.
2. **Drainage Regulator:** it is provided across the drainage just at downstream side of the crossing point. The regulator consists of adjustable shutters at different tiers.
3. **Canal Regulator:** it is provided across the canal just at downstream side of the crossing point. The regulator consists of adjustable shutters at different tiers.

b) **Inlet and Outlet:**

In the crossing of small drainage with small channel no hydraulic structure is constructed. Simple openings are provided for the flow of water in their respective directions. It is not necessary for the number of inlets and outlets to be same. There may be one outlet for two or three inlets. A canal inlet is constructed when the cross drainage flow is small and its water may be absorbed into the canal without causing appreciable rise.



Advantages of Type3:

- Low initial cost

Disadvantages of Type3:

- Regulation of such work is difficult & requires additional staff
- The canal has to be designed to carry the increased flood discharge of drain.
- The faulty regulation of the gates may damage the canal.
- There is additional expenditure of silt clearance.

Suitability of Cross-Drainage Works:

The factors which affect the selection of the suitable type of cross drainage works are:

1. *Relative bed levels and water levels of the canal and drainage*
2. *Size of the canal and the drainage*

The following considerations are important,

1. When the bed level of the canal is much above the highest flood level (H.F.L) of the drainage, so that sufficient headway is available for floating rubbish etc and also for the structural elements of the work. An '*aqueduct*' is the obvious choice. Similarly, if the bed level of the drain is well above the Flood surface level (F.S.L) of the canal, '*Super-passage*' is provided.
2. The necessary headway between the canal bed level and the drain H.F.L can be increased by shifting the crossing to the downstream of the drainage. If, however, it is not possible to change the canal alignment or if such a shifting does not give sufficient headway between the two levels, a '*siphon aqueduct*' may be provided. Thus in case of siphon aqueduct, the H.F.L of the drain is above channel (canal) bed.
3. When the canal bed level is much lower but the F.S.L of the canal is higher than the bed level of drainage, a '*canal siphon*' is preferred.
4. When the drainage and the canal cross each other practically at the same level a '*level crossing*' may be preferred. This type of work is avoided as far as possible.

The considerations governing the choice between aqueduct and siphon aqueduct (or a super passage and siphon-super passage) are,

- (i) *Suitable canal alignment*
- (ii) *Suitable soil available for bank connections and*
- (iii) *Nature of available foundation*

As discussed earlier, the relative difference between the bed level of the canal and the H.F.L of the drainage can be suitable altered by changing the canal alignment so that the point of crossing is shifted upstream or Downstream of the drainage.

For example, if the canal alignment is such that headway is not available between the H.F.L of the drain and the bed of the canal, a siphon aqueduct is to be constructed at the crossing.

But if the other conditions are not favorable for the construction of the siphon aqueduct, the canal alignment may be changed so that the crossing is shifted to the downstream and sufficient headway required for the construction of an aqueduct is available.

PROPER SITE FOR DRAINAGE CROSSING:

The site selected for the cross drainage works should have the following main characteristics,

1. It should be such that it requires minimum disturbance regarding the approach and tail reaches of the drainage channel.
2. Suitable foundation soil should be available at reasonable depth.
3. Sufficient headway is available for the super structure of the aqueduct over the H.F.L of the natural stream.
4. Suitable existing topography, geological and hydraulic conditions for the cross drainage works at reasonable costs.

Super Passage : A super passage is just opposite of the aqueduct. In this case, the bed level of the drainage is above the fully supply level of the canal. The drainage is taken through a rectangular or trapezoidal trough of channel which is constructed on the deck supported by piers. The section of the drainage trough depends on the high flood discharge. The bed and banks of the canal below the drainage trough should be protected by boulder pitching or lining with concrete slabs.

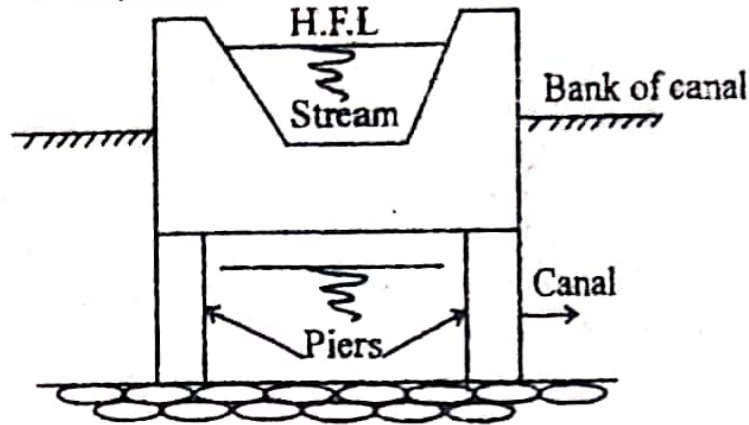


Fig. Super passage

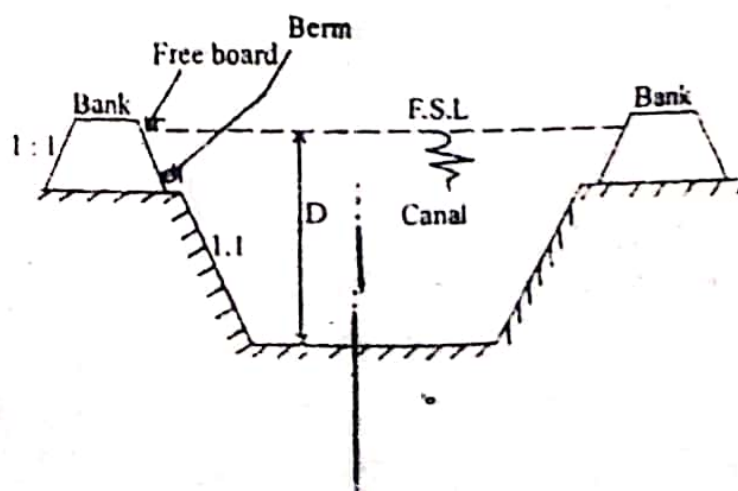
6. (a) Define confined and unconfined aquifer.

Ans. Confined Aquifer : It is overlain by a confining layer which is generally semi-permeable allowing vertical fluxes between the adjacent layers. Unless an irrigation abstraction, the confined aquifers are under pressure, this means that the water level in a piezometric well will rise above the top of the aquifer.

Unconfined Aquifer : It is close to the land surface, being under the direct influence of the climatic factors. The ground water fluctuations follow with a certain lag, depending on the depth and the nature of the unsaturated zone, the variation of the fallen precipitations. The unconfined aquifer extend from the water table to the base of the aquifer, represented by an impermeable boundary.

(b) Show the typical cross-section of a canal partly in cutting and partly in filling and show the term berm, free-board.

Ans.



separating ...
(e) Classify canals according to their alignment.

Ans. Classification of canals according to their alignment.

(a) Ridge or watershed canal

(b) Contour canal

(c) Side slope canal

(f) Define the term 'catchment area'.

Ans. The catchment area of a river means the area from where the surface runoff flows to that river through tributaries, streams, springs etc. The area is bounded by watershed line.

(g) What is 'permanent wilting point' ?

Ans. The permanent wilting point is defined as the amount of moisture held by soil which can not be extracted by the plant roots for transpiration. At this point the wilting of plant occurs. It is also expressed in percentage.

(h) What do you mean by 'aquiclude' ?

Ans. Aquiclude is an impervious formations which may contain water but these aren't capable of transmitting water through them.

(i) What is 'radius of influence' ?

Ans. Radius of Influence : The base of cone of depression is known as the circle of influence. The radius of this circle is known as radius of influence.

(j) What is 'canal escape' ?

Ans. Canal escape can be stated that escapes are the safety valves of canals and must be provided at regular intervals depending upon the importance of the channel availability of a suitable drainage for the disposal of the escaped water.

(c) Cross regulator

Ans. In an irrigation project when the network of main canals, branch canals, distributories etc are provided, then these canals may have to cross the natural drainage like rivers, streams etc at different points within the command area of the project. Suitable structures must be constructed at the crossing point for the easy flow of water of the canal and drainage in the respective directions. These structures are known as cross regulator or cross drainage works.

(d) Spillway

Ans. This spillway is simply a rectangular open channel provided on the dam to discharge the surplus water from the reservoir to the same river on the downstream side. The spillway may be provided along the abutment of the dam or along the edge of the reservoir at the full supply level.

(e) Tube-well

Ans. A tube well consists of GI pipes of diameter varying from 3.75 cm to 15 cm and length varying from 7m to 8m. The tube well is sunk into the ground by boring. The joints of the pipes are socket joints, it penetrates a number of water bearing strata which are sandwiched between the impervious layers.

Again the tube well may be shallow or deep. The diameter of shallow tube well varies from 3.75cm to 5cm and depth varies from 30m to 40m. The diameter of deep tubewell varies from 10cm to 15cm and depth varies from 200m to 300m.

Discharge of shallow tubewell is dependent on the water table. If the water table goes below the section head in summer, the tubewell is likely to be default. A deep tube well draws water from the deeper most aquifers. Hence the water is available throughout the year.

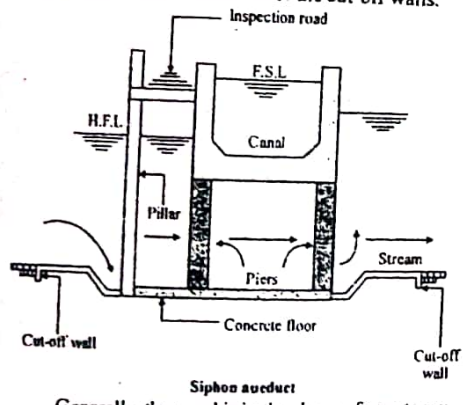
land is flat i.e. with no country slope and consists of depressions or undulations, then this leads to water logging.

12. Occasional flood - If an area gets affected by flood every year and there is no proper drainage system, the water table gets raised and this causes water logging.

6. Explain with neat sketch the working process of a canal syphon.

Ans. Siphon Aqueduct :

The siphon aqueduct, the bed of the drainage is depressed below the bottom level of the canal through by providing sloping apron on both sides of the crossing. The sloping apron may be constructed by stone pitching or cement concrete. The section of the drainage below the canal through is constructed with cement concrete in the form of tunnel. This tunnel acts as a siphon. Cut off walls are provided on both sides of the apron to prevent scouring. Boulder pitching should be provided on the upstream and downstream of the cut-off walls.



Siphon aqueduct

Generally, the canal is in the shape of a rectangular through which is constructed with reinforced cement concrete. Sometimes, the trough may be of trapezoidal section. An inspection road is provided along the side of the trough. The bed and banks of the drainage below the through is protected by coulder pitching with cement grouting. The section of the trough is designed according to the full supply discharge of the canal. A free board of about 0.50 m should be provided. The height and section of piers are designed according to the highest flood level and velocity of flow of the drainage. The piers may be of brick masonry stone masinary or reinforced ce-

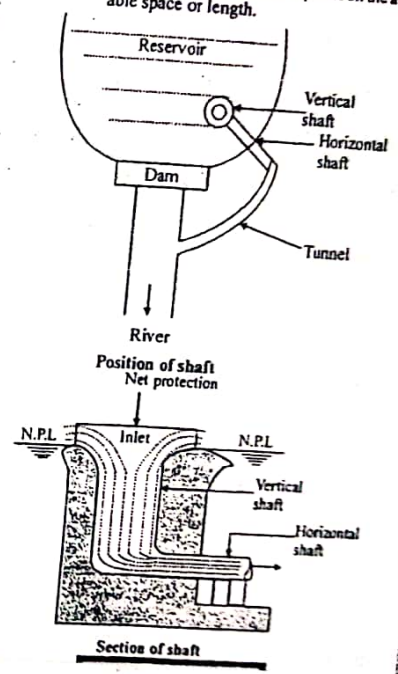
ment concrete. Here deep foundation (like well foundation) is not necessary for the piers. The concrete foundation may be done by providing the depth of foundation according to the availability of hard soil.

7. Write down the names of various types of spillways and give the neat sketch of any one.

Ans. Types of spillway -

- i. Drop spillway - In drop spillway the overflowing waterfalls freely and almost vertically on the downstream side of the hydraulic structure. This type of spillway is suitable for weirs or low dams.
- ii. Ogee spillway - It is a modified form of drop spway. Here the downstream profile of the spillway is made to coincide with the shape of the lower nappe of the free falling waterjet from a sharp crested weir.
- iii. Siphon spill way - The spillway which acts on the principle of siphon is known as siphon spillway. The siphon spillway may be of two types.
 - (a) Sadle siphon spillway
 - (b) volute siphon spillway
- iv. Chute spillway - This spillway is simply a rectangular open channel provide on the dam to discharge the surplus water from the reservoir to the same river on the downstream side. The spillway may be provided along the abutment of the dam or along the edge of the reservoir at the full supply level.
- v. Shaft spillway - It consists of a vertical shaft which is constructed with masonry work or plain cement concrete or reinforced cement concrete on the bed of the reservoir just at the upstream side of the dam. The inlet mouth of the vertical shaft is conical shaped. The vertical shaft is connected with horizontal shaft. The horizontal shaft again may be taken through the body of the dam or may be connected to a tunnel outside the dam. The inlet mouth is kept at the normal pool level(NPL) of the reservoir. So when the water rises above NPL, it enters the shaft from all directions and flows out through the shaft. In order to arrest the floating debris a net protection is provided on the inlet mount.
- vi. Side channel spillway - The side channel spillway is completely separated from the main body of the dam. The spillway is constructed at right angle to the dam and at any side according to the site condition. The crest of the spillway is kept at the normal pool level of the

reservoir. When the water raises above NPL, it spills over the rest of the spillway and flows through the side channel and ultimately meets the same river on the downstream side. This type of spillway is recommended for the sites where other types of spillways are found unsuitable. The side walls are constructed with brick masonry or stone masonry. The longitudinal slope of the channel depends on the available space or length.



be discharged to any river.

(e) What is meant by cross-drainage works? Explain its necessity.

Ans. A cross drainage work is a structure which is constructed at the crossing of a canal and a natural drain. So as to dispose of drainage water without interrupting the continuous canal supplies.

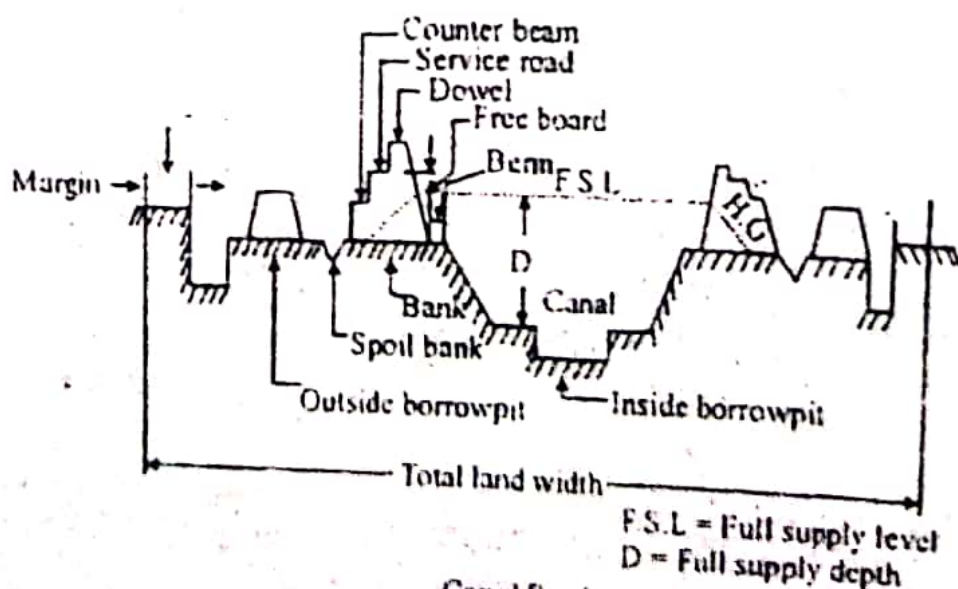
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- iii. The site condition of the crossing point may be such that without any suitable structure the water of the canal and drainage cannot be diverted to their natural directions. So the cross drainage works must be provided to maintain their natural direction of flow.

(f) Draw a neat sketch for a canal in embankment.

Ans.



3. With neat hand sketches explain diff.

Stone apron