RECLAIMATION OF WATER-LOGGED AND SALINE SOILS FOR AGRICULTURAL PURPOSES.

Definition :-

An agricultural land is said to be water-logged, when its productivity gets affected by the high watertable.

PROBLEMS CREATED BY WATER-LOGGING

1. Productivity of land, gets affected when the root zone of the plants gets flooded with water, & thus become ill-aerated.
2. Normal cultivation operations, such as tilling, ploughing etc. cannot be easily carried out in wet soils.
3. Certain water loving (hydrophilic) plants like grasses, weeds etc. grow profusely in water-logged lands, thus affecting and interfering with the growth of crops.
4. Water-logging also leads to salinity; as explained below:

If watertable has risen up, or if the plant roots happen to come within the capillary fringe, water is continuously evaporated by capillarity. Thus, a continuous upward flow of water from watertable to the land-surface, gets established. With this upward flow, ~~of water from the watertable~~ the salts which are present in the water, also rise towards the surface, resulting in the deposition of salt in the root zone of the crops. The concn of these alkali salts present in the root zone of the crops reduces the osmotic activity of the plants and checks the plant growth. Such soils are called saline soils.

It becomes evident that water-logging ultimately leads to salinity, the result of which is, the reduced crop yield.
For this reason, salinity and water-logging are treated as a twin problem, under the head 'salinity & water-logging'. Whenever there is water-logging salinity is a must.

CAUSES OF WATER-LOGGING

1. Over and Intensive Irrigation.

Extensive Irrigation (i.e; irrigation spread over wider regions) should preferred over Intensive Irrigation (maximum irrigable area of a small region is irrigated)
Intensive irrigation leads to too much of irrigations in that regions, resulting in heavy percolation and subsequent rise of watertable.

The various measures adopted for controlling water-logging are enumerated below:

(1) Lining of canals & water courses:

Attempts should be made to reduce the seepage of water from the canals & water courses. This can be achieved by lining them.

(2) Reducing the Intensity of Irrigation: (It should be reduced in waterlog prone areas. Only small portion of irrigable land should receive canal water in one particular season. The remain areas can receive water in the next season, by rotation).

(3) By introduction of Crop Rotation.

(4) By optimum use of water.

(5) By providing intercepting drains.

Intercepting drains along the canals should be constructed, wherever necessary. These drains can intercept and prevent the seeping canal water from reaching the area likely to be water-logged.

(6) By provision of an Efficient Drainage System.

An efficient drainage system should be provided in order to drain away the storm water & the excess irrigation water. A good drainage system consists of surface drains as well as sub-surface drains.

(7) By improving natural drainage of the area.

To reduce the percolation, the water should not be allowed to stand for a longer period. Some relief in this direction can be obtained by removing the obstructions from the path of natural flow. This can be achieved by removing bushes, jungles, forests etc. and improving the slopes of the natural drainage lines.

(8) By Adopting Conjunctive Use of Surface & Sub-surface water.

The introduction of lift irrigation to utilize ground water helps in lowering the water-table in a canal irrigated area, where the water table tends to go up. Hence the ground water should also be used in conjunction with canal water for irrigation, as the continuous use of ground water will not allow any appreciable rise in the level of the water-table, due to continuous seepage of canal water.

— This combined use of subsurface water (ground water) and surface water (canal water) in a judicious manner, as to derive maximum benefits, called "conjunctive use", should hence be adopted to control "water logging".

2. Seepage of water from the Adjoining High lands.
Water from the adjoining high lands may seep into the sub-soil of the affected land & may raise the water table.

3. Seepage of water through the canals.
Water may seep through the beds and sides of the adjoining canals, reservoirs etc. situated at higher level than the affected land; resulting in high watertable. This seepage is excessive, when soil at the site of canals, reservoirs, etc. is very pervious.

4. Impervious Obstruction
Water seeping below the soil moves horizontally (i.e; laterally) but may find an impervious obstruction, causing the rise of watertable on the u/s side of the obstruction.

5. Inadequate Natural Drainage.
Soils having less permeable sub-stratum (such as clay) below the top layers of pervious soils, will not be able to drain the water deep into the ground, and hence, resulting in high water level in the affected soil.

6. Inadequate Surface Drainage.
Storm water falling over the land and the excess irrigation water should be removed & should not be allowed to percolate below. If proper drainage is not provided, the water will constantly percolate and will raise the level of the underground reservoir.

7. Excessive Rains.
Excessive rainfall may creat temporary water-logging, and in the absence of good drainage, it may lead to continued water-logging.

8. Submergence due to Floods.
If a land continuously remains submerged by floods, water loving plants like grasses, weeds, etc. may grow, which obstruct the natural surface drainage of the soils and thus, increasing the chances of water-logging.

9. Irregular or Flat Topography.
In steep terrain, the water is drained out quickly. On flat or irregular terrain having depressions, etc. the drainage is very poor. All these factors lead to greater detention of water on the land, causing more percolation and raised watertable.

WATER-LOGGING CONTROL

- Water-logging can be controlled only if the quantity of water into the soil below is checked and reduced.
- To achieve this, the inflow of water into the underground reservoir should be reduced and outflow from this reservoir should be increased, as to keep the highest position of water-table atleast about 3m below the ground surface.

Reclamation of Saline and Alkaline Lands.

- Land reclamation is a process by which an unculturable land is made fit for cultivation. Saline & water logged lands give very less crop yields, and are, therefore, almost unfit for cultivations unless they are reclaimed.

How land become 'saline' or in extreme case 'alkaline'?

- Every agricultural soil contains certain mineral salts in it. Some alkali salts such as Na_2CO_3, Na_2SO_4 and NaCl prove injurious to plant growth. Na_2CO_3 (black alkali) is the most harmful; and NaCl is the least harmful. These salts are soluble in water. If the watertable rises up, or if the plant's roots happen to come within the capillary fringe, water from the watertable starts flowing upward. The soluble alkali salts also move up with water and get deposited in the soil within the plant roots as well as on the surface of the land. This phenomenon of salts coming up in solution and forming a thin (5 to 7.5 cm) crust on the surface, after the evaporation of water, is called efflorescence. Land affected by efflorescence is called "saline soil". The salty water surrounding the roots of the plants reduce the osmotic activity of the plants. Such a salt affected soil is unproductive and is known as "saline soil"

Alkaline Soils

- If the salt efflorescence continues for a longer period, a base exchange reactions set up, particularly if the soil is clayey, thus sodiumising the clay, making it impermeable and, therefore, ill-aerated & highly unproductive. Such soils are called alkaline soils. The reclamation of alkaline land is more difficult.

Reclamation of salt affected lands.

- Efflorescence can be avoided if the watertable is maintained sufficiently (about 3m) below the roots, so that the capillary water is not able to reach root zone of the plant.
- An efficient drainage system consisting

- Salts are soluble in water
- water table rises up (or if plant root happen to come within capillary fringe)
- water starts flowing upward.
- soluble alkali salts also move up with water
- get deposited in the soil within plant roots as well as on the surface of the land.
- Efflorescence

LAND DRAINAGE

- Excess water from the irrigation land is removed and drained out from below the soil & discharged back either into a river, a canal etc. or somewhere else. Hence while designing a CIS, it is desirable to provide a suitable drainage system.

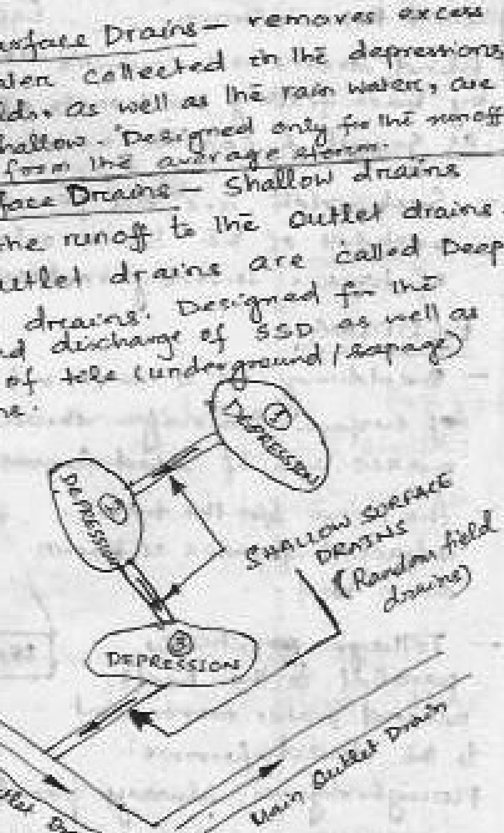
- 2 types of drainages can be provided i.e;
(1) Surface Drainages
(2) Sub-Surface Drainages, called Tile-drainage or Underground Drainage.

SURFACE DRAINAGE (OR) OPEN DRAINAGE

- Removal of excess water (rain water or irrigation water) applied to the fields, by constructing open ditches, field drain & other related structures.
- Surface Drains are designed as "Shallow Surface Drains" → should not be deep enough, as to interfere with agricultural operations.
- The land is sloped towards the ditches or drains, as to make the excess water flow into these drains → Land Grading (continuous land slope towards the field drains) is an important part of surface drainage system.

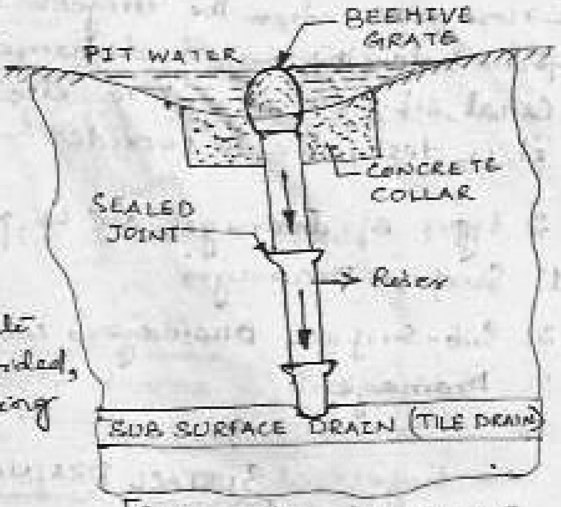
OPEN DRAINS
- → Shallow Surface Drains — removes excess irrigation water collected in the depressions on the fields. As well as the rain waters, are broad & shallow. Designed only for the runoff resulting from the average storm.
- → Deep Surface Drains — Shallow drains carry the runoff to the outlet drains. These outlet drains are called Deep surface drains. Designed for the combined discharge of SSD as well as that of tile (underground / seepage) drains.

SURFACE INLET (Intake structure)
- Surface water from the pot holes, depressions or ditches etc. may be removed either by connecting them with SSD (sometimes called random field drains). or by constructing an intake structure called an open inlet or surface inlet.



Random field — drains (Shallow surface drains) system for surface drainage.

- A surface inlet is a structure constructed to carry the pit water into the sub-surface or tile drain.
- At the surface of the ground, a concrete collar extending around the intake is constructed on the riser to prevent the growth of vegetation & hold it in place.
- On the top of the riser, beehive grate or some other suitable grate is provided, so as to prevent trash from entering the tile.

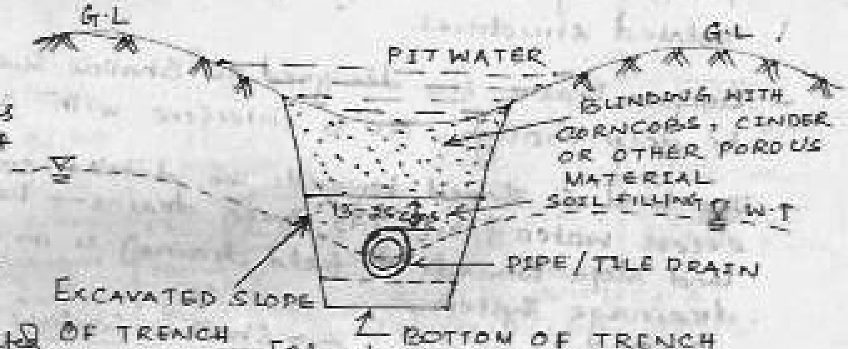


[Surface Inlet draining the surface water onto a tile drain]

FRENCH DRAIN

- When the quantity of water to be removed from the pits or depressions is small, a blind inlet may be installed over the tile drain.

Blind inlet is also known called French Drain.

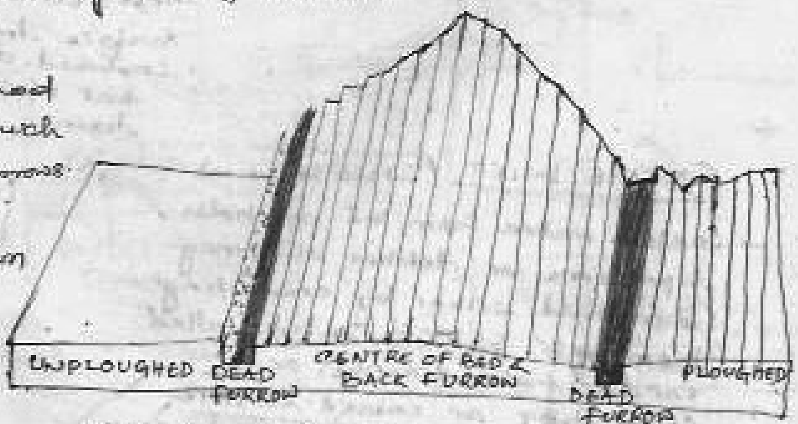


[Blind Inlet or French Drain].

- Blind drains are constructed by back filling the trench of the tile drain with graded materials, such as gravel & coarse sand, or with corn cobs, straw.
- Such inlets are not permanently effective since the voids in the backfill of the blind inlet become filled up with the passage of time, thereby reducing its effectiveness.

BEDDING

- Bedding is a method of surface drainage which makes use of dead furrows.
- The area b/w the two adjacent furrows is known as a bed.
- Tillage practices, parallel to the beds, retard water movement to the dead furrows.



[C/S of bed showing method of Construction]

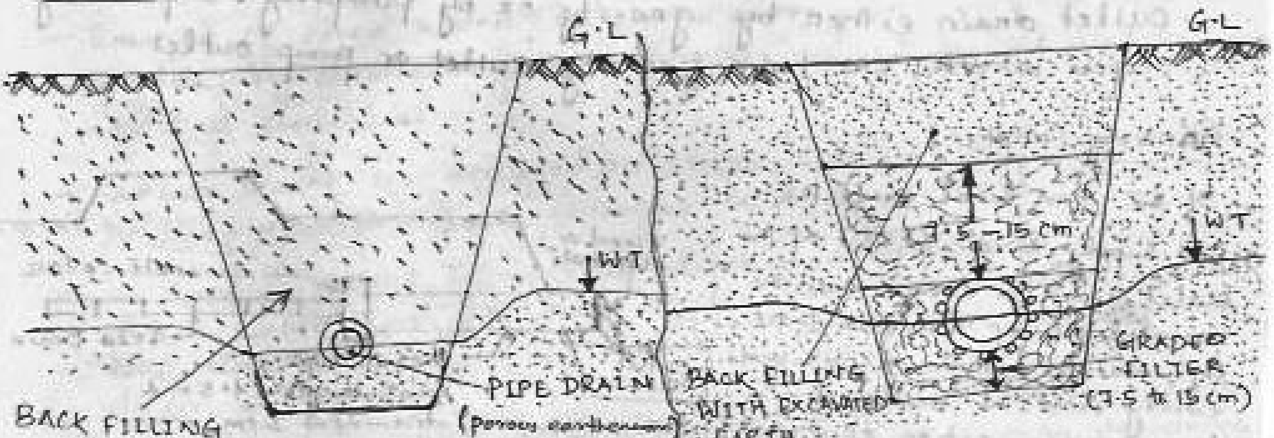
Ploughing is always parallel to the dead furrows.

- Bedding is most practicable on flat slope of less than 1.5%, where the soils are slowly permeable & tile drainage is not economical.

SUB-SURFACE DRAINAGE (OR) TILE DRAINAGE

- Surface drains are, therefore, needed for removing the excess farm water, for most of the cultivated crops on flat or undulating topography.
- Sub-surface drains, on the other hand, are required for soils with poor internal drainage & a high watertable.
- Providing underground tile drains, however, is a costly proposition & may be required only in the areas of high water table, & where the ground soil has a poor internal drainage capacity.

ENVELOPE FILTERS



[C/S of a tile drain in pervious soils]
(without any filter)

[C/S of a tile drain in less pervious soils]
(with graded filter)

- Tile drains, are usually, pipe drains made up of porous earthenware and are circular in section.
- Diameters may vary from 10 – 30 cm.
- These drains are laid below the ground level, and as far as possible, the tile drains should not be placed below less pervious strata.
- The trenches in which they are laid, are back-filled with sand & excavated materials.

Tile drains in less pervious soil

- When tile drains are placed in less pervious soil, they are surrounded by graded gravel filters, called "Envelope filters"
- Envelope filters serves 2 functions :-

(1) it prevents the inflow of the soil into the drain, and

(2) it increases the effective tile diameter, and thus increases the inflow rate.

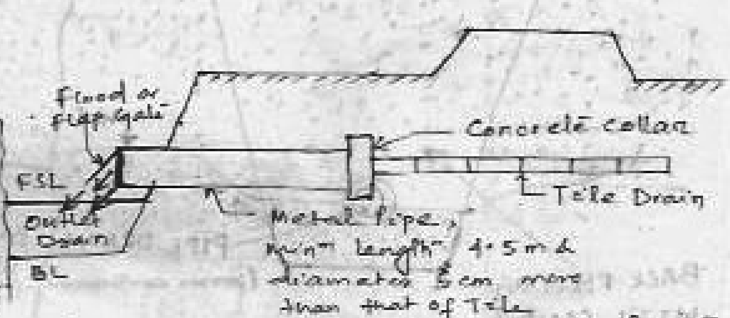
- The filter consists of different gradations, such as gravel, coarse sand etc.
- The coarsest material is placed immediately over the tile, and the size is gradually reduce towards the surface
- The minimum thickness of the filter is about 7·5 cm.

Outlets for Tile Drains or Closed Drains.

- The water drained by the tile drains is discharged into some bigger drains, called Deep Surface Drains
- The water from a tile drain may be discharged into an outlet drain either by gravity or by pumping, depending upon which, we have gravity outlet or pump outlet.

Gravity Outlet.

- If the bed level and the full supply level (FSL) of the outlet drain is lower than the invert level of the tile drain, then water can be discharged easily into the outlet drain by the mere action of gravity.

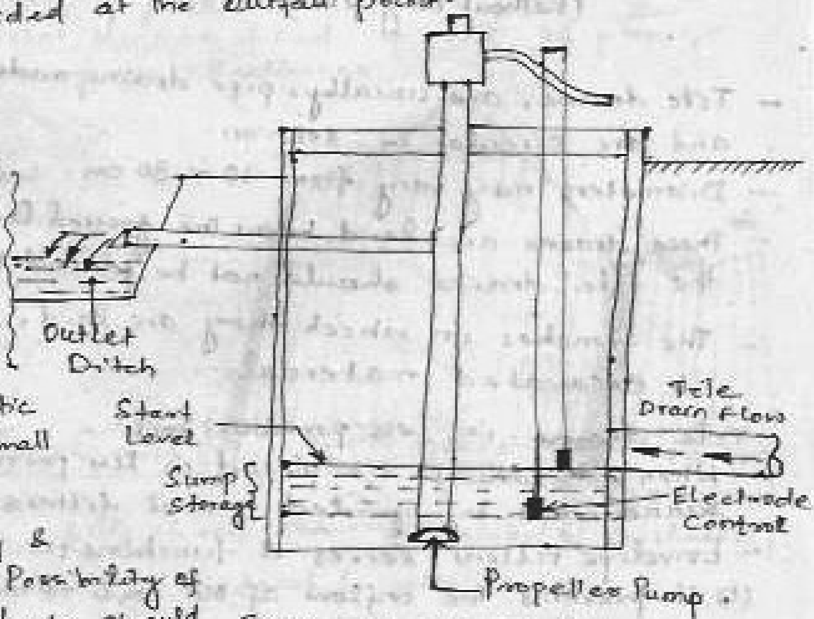


[Gravity Outlet (outfall) for tile drain]

- Corrugated metal pipe with a flap shutter to prevent entry of rodents & back flow from the outlet drain into the tile drain, is generally provided at the outfall point.

Pump Outlet

- When the bed level of the outlet drain is higher than that of the pump outlet discharging tile drain; a pump outlet has to be installed.



[Pump Outlet (outfall) for tile drain]

- It consists of an automatic controlled pump with a small sump for storage.
- Pump outlets are costly & require technicality. Possibility of deepening the outlet drain should be investigated.
- The cost of installing & maintaining a pump outlet should be compared with that of excavating & maintaining a deeper outlet drain, before making a final ~~outlet~~ selection.

Drainage

It is the process of removal of excess water as free or gravitational water from the surface and the sub-surface of farm lands with a view to avoid waterlogging & create favorable soil conditions for optimum plant growth.

- In arid regions, it is assumed that waterlogging is not a problem!
- Irrigation & drainage are complementary practices in arid region to have optimal soil water balance

Drainage is required under the following condition

- High water table
- water ponding on the surface for longer periods.
- Excessive soil moisture content above F.C, not draining easily as in clay soil
- Areas of salinity & alkalinity where annual evaporation exceeds rainfall & capillary rise of groundwater occurs.
- Humid regions with continuous of intermittent heavy rainfall.
- Flat land with fine texture soil
- Low lying flat areas surrounded by hills.

Drainage →
- Surface Drainage →
  - Shallow surface Drains
  - Open inlet / surface inlet.
  - Deep surface Drains
- Sub-surface Drainage / Tile drains / underground drains.

SURFACE DRAINAGE.

It is suitable for :-

(i) Slowly permeable clay & shallow soil

(ii) Regions of high intensity of rainfall.

(iii) fields where adequate outlets are not available.

(iv) Land with less than 1.5% slope.

Advantages

→ Low initial cost

→ Easy for inspection

→ Effective in low permeable area.

Disadvantages.

→ Low efficiency

→ Loss of cultivable land.

→ Interference to cultural operation.

→ High maintenance cost

SUB-SURFACE DRAINAGE -

Movement of water into sub-surface drains is influenced by:

- Hydraulic conductivity of soil
- Depth of drain b/l ground surface
- Horizontal distance b/w individual drains.

Underground drainage is mostly needed to the

- Medium textured soil
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Advantages-

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- Maintenance cost is less.
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- Initial cost is high
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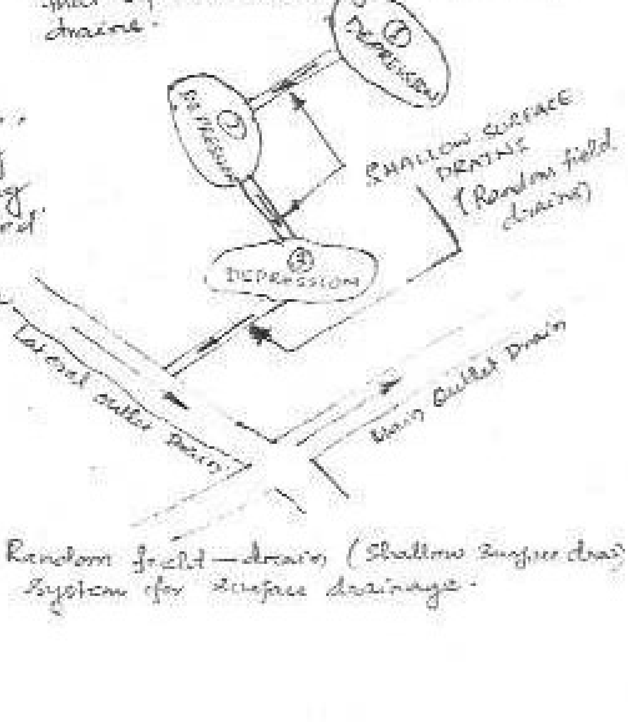

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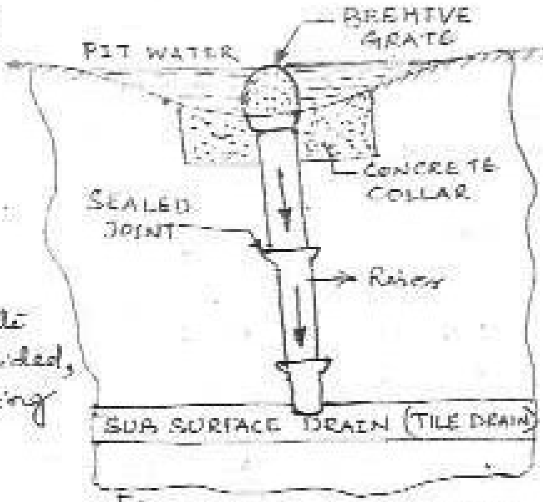

[Surface Inlet draining the surface water onto a tile drain]

Blinding – A thin coat of sand & fine gravel over a newly paved road.
– covering with some materials (protective covering).

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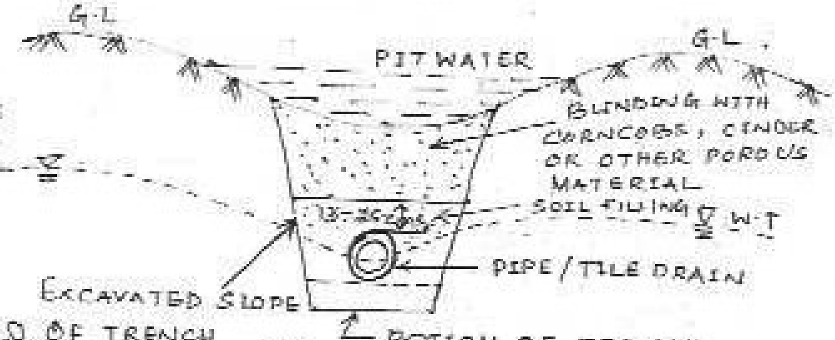

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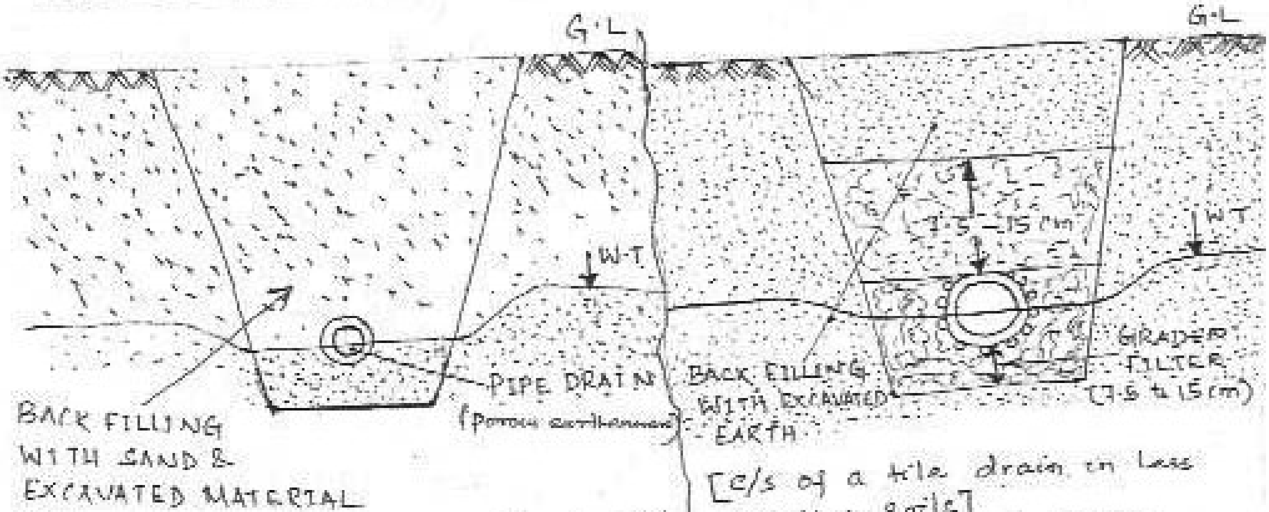

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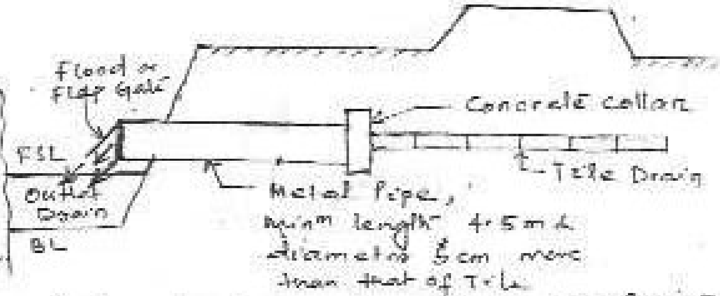

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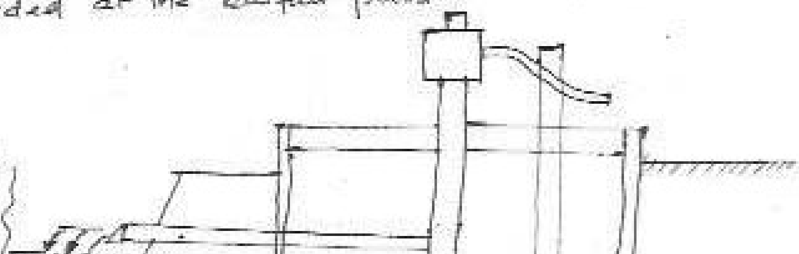

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→ Advantages

- → Low initial cost
- → Easy for inspection
- → Effective in low permeable area.

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- Open ditches, field drains & other related structures.

EARTHEN DAMS.

TYPES OF EARTHEN DAM

(1) HOMOGENEOUS EMBANKMENT TYPE.

- Simplest type of an earthen embankment consists of a single material & homogeneous throughout.
- Sometimes a blanket of relatively impervious materials may be placed on u/s face.
- Such a section is used for low to moderately high dams.
- A purely homogeneous section poses the problems of seepage. Due to this homogeneous section is provided with an internal drainage system so as to keep the phreatic line well within the body of the dam.

(2) ZONED EMBANKMENT TYPE

- Zoned embankments are usually provided with a central impervious core, covered by a comparatively pervious transition zone, which is finally surrounded by a much more pervious outer zone.

Central core → checks the seepage.

Transition zone → prevents piping through cracks which may develop in the core.

Outer zone → gives stability to the central impervious fill & also distribute the load over a large area of foundation.

Transition zones are provided, whenever there is abrupt change of permeability from one zone to another.

- Materials for,

(i) Central core = Silts or Silty clays.

(ii) Outer shells = Coarse sands & gravels.

(iii) Transition = filters

(3) DIAPHRAGM TYPE EMBANKMENTS.

- Have a thin impervious core, which is surrounded by earth or rock fill.
- Impervious core called diaphragm, is made up of impervious soils, concrete, timber etc.
- Acts as a water barrier to prevent seepage through dam.
- The diaphragm must also be tied to the bed rock or to a very impervious foundation material if excessive under seepage through the existing pervious foundation has to be avoided.

• CAUSES OF FAILURE OF EARTHEN DAMS.

The various causes leading to the failure of earthen dams can be grouped into;

1) Hydraulic failures (40%)
2) Seepage failures (40%)
3) Structural failures. (20%)

HYDRAULIC FAILURES :- About 40% of earth dam failures have been attributed to these causes.

The failure under this category, may occur due to following reasons;

(a) By Overtopping :- Water may overtop the dam, if the design flood is underestimated or if spillway is of insufficient capacity or if spillway gates are not properly operated. Sufficient free board, should, therefore, be provided as an additional safety measure.

(b) Erosion of u/s face :-

LINE OF SEEPAGE (OR) PHREATIC LINE IN EARTH DAMS.

- Line of seepage or phreatic line or saturation line is defined as the line within the dam section below which there are positive hydrostatic pressures in the dam.

- The hydrostatic pressure on the phreatic line is equal to the atmospheric pressure and hence, equal to zero.

- Above the phreatic line, there is a zone of capillary saturation called capillary fringe, in which the hydrostatic pressures are negative.

- The appreciable flow through the dam body below the phreatic line, reduces the effective weight of this soil, and thus reduces the shear strength of the soil due to pore pressure.

- But on the other hand, the insignificant flow through the capillary fringe, leads to greater shear strength, because the capillary tension in water leads to increased intergranular pressure. The effects of the capillary fringe are thus on a slightly safer side and hence neglected.

It is essential to determine the position of the phreatic line, as its position will enable us to determine the following things:

(i) It gives a divide line between the dry (or moist) & submerged soil; for computation of shear strength of soil.

(ii) It represents the top streamline & hence, helps in drawing the flow net.

(iii) The seepage line determination, helps to ensure that it doesnot cut the d/s face of the dam. This is extremely necessary for preventing softening or sloughing of the dam.

Determination of Phreatic Line when the Dam section is Homogeneous and provided with a Horizontal Filter.

- The seepage line is pushed down by filter and it is very nearly parabolic except near its junction with the u/s face.

SEEPAGE ANALYSIS.

- Seepage occurs through the body of all earthen dams and also through their pervious foundation.
- The amount of seepage has to be controlled in all conservation dams and the effects of seepage (i.e, position of phreatic line) has to be controlled for all dams, inorder to avoid their failures.
- The seepage through a pervious soil material, for 2-Dimensional flow, is given by Laplacian eqn

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$

where $\phi = K \cdot h$ = velocity Potential.
K = Permeability of the soil.
h = Head causing flow.

The above equation is based on following assumptions:

(i) Water is incompressible.

(ii) Soil is incompressible and porous.
(The size of the pore space donot change with time regardless of water pressure).

(iii) The quantity of water entering the soil in any given time is the same as the quantity flowing out of the soil.

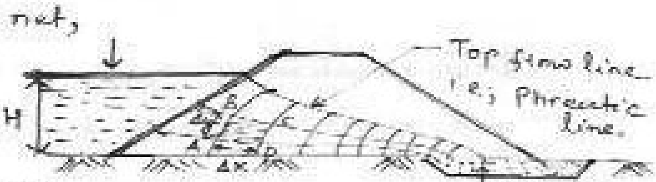
(iv) Darcy's law is valid for the given soil.

(v) The hydraulic boundary conditions at the entry & exit are known.

→ **Seepage Discharge Through the Isotropic Soils.**

Discharge passing through a flow net,

$$q = \frac{K \cdot H}{N_d} N_f$$



N_d = Total no. of drops in the complete flownet.
N_f = No. of flow channels.

-- The above eqn is applicable to isotropic soils (i.e; $K_H = K_V$).

→ **Seepage Discharge for Non-isotropic soils.**

$$q = \sqrt{K_H \cdot K_V} \; \frac{H N_f}{N_d}$$