$Q = kiA$

$q = k\frac{dh}{dx}$

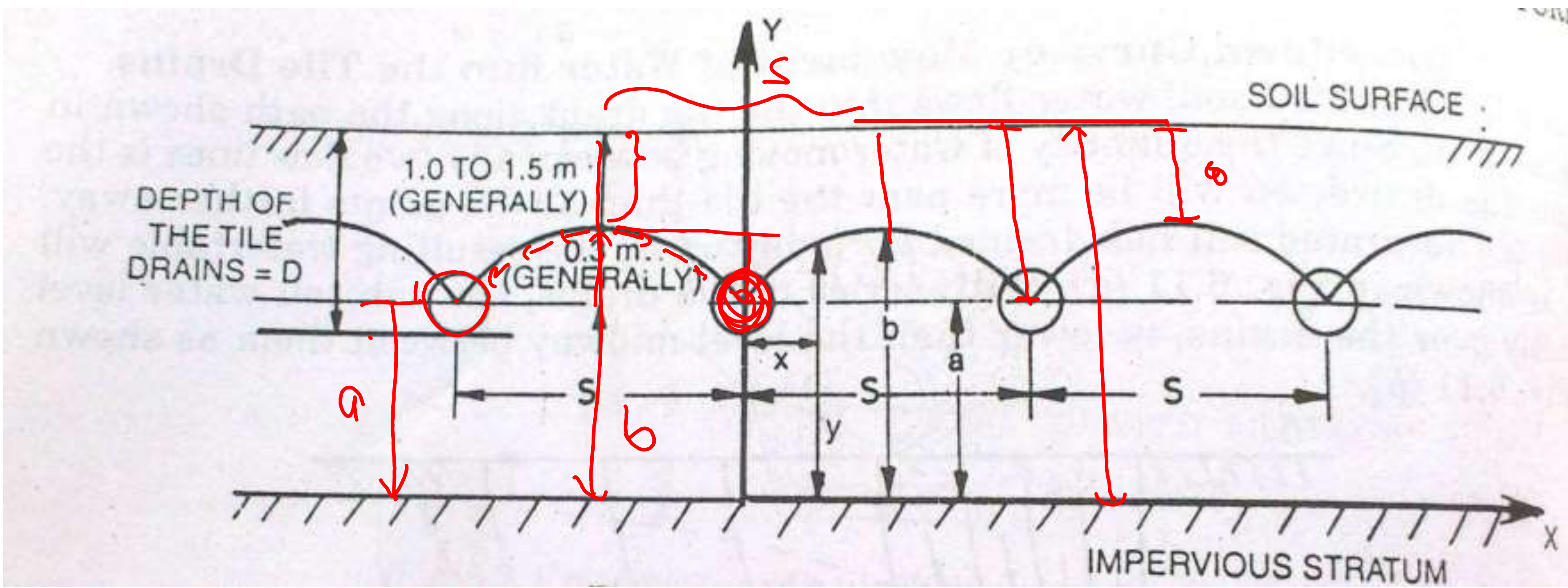
Spacing of drains derivation:

Let 's' be spacing between the drains.

'a' be the depth of impervious stratum from center of drain.

'b' be maximum height of lowered water table above impervious stratum.

At any distance 'x' from center of drain let the height of water table be 'y'



$$Q = KI \cdot A$$

where K = permeability coefficient in m/sec.

$\therefore$ Discharge per unit length of the drain passing the section at y (q_y) is given as :

$$q_y = K \cdot \frac{dy}{ds} \cdot y$$

Assuming the inclination of the water surface to be small, such that the tangent $\left(i.e.\ \frac{dy}{dx}\right)$ can be used in place of sine $\left(i.e.\ \frac{dy}{ds}\right)$ for the hydraulic gradient, we get

$$q_y = K \cdot \frac{dy}{dx} \cdot y \qquad \text{...(6.5)}$$

But when $x = \frac{S}{2}$, $\quad q_y = 0.$

and, when $x = 0$, $\quad q_y = \frac{q}{2}$

where q *is the total discharge per unit length carried by the drain*, so that $\frac{1}{2}q$ enters the drain from either side.

Also assuming that q is inversely proportional to the distance from the drain, we can write

$$q_y = \frac{1}{2}q - \frac{1}{2}q\frac{x}{S/2} = \frac{1}{2}q\left(1 - \frac{x}{S/2}\right)$$

or

$$= \frac{q}{2S}\left[S - 2x\right] \qquad \text{...(6.6)}$$

Equating Eqs. (6.6) and (6.5), we get

$$\frac{q}{2S}(S - 2x) = K\,y \cdot \frac{dy}{dx}$$

Rearranging and integrating, we get

$$\int \frac{q}{2SK}(S - 2x)\,dx = \int y\,dy.$$

Assuming the soil permeability to be constant, we get

$$\frac{q}{2K.S}\left[Sx - \frac{2x^2}{2}\right] = \frac{y^2}{2} + C \qquad \text{...(6.7)}$$

when $x = 0$, $\quad y = a$

$$\therefore \quad \frac{q}{2KS}[0] = \frac{a^2}{2} + C \quad \text{or} \quad C = -\frac{a^2}{2}$$

Substituting $C = -\frac{a^2}{2}$, equation (6.7) becomes

$$\frac{q}{2KS}\left[Sx - x^2\right] = \frac{y^2}{2} - \frac{a^2}{2}$$

or

$$\frac{q}{2KS}\, x\,(S - x) = \frac{y^2 - a^2}{2}$$

or

$$q = \frac{KS\,(y^2 - a^2)}{(S - x)\,x} \qquad \text{...(6.8)}$$

Also, when $x = \frac{S}{2}$, $y = b$, equation (6.8) then becomes

$$q = \frac{KS\cdot(b^2 - a^2)}{\left(S - \frac{S}{2}\right)\frac{S}{2}} \quad \text{or} \quad q = \frac{KS\,(b^2 - a^2)}{\frac{S^2}{4}}$$

or

$$\mathbf{q = \frac{4K}{S}\,(b^2 - a^2)} \qquad \text{...(6.9)}$$

or

$$S = \frac{4K}{q}\,(b^2 - a^2) \qquad \text{...(6.10)}$$

Equation (6.10) can be used to predict the spacing (S) between the drains, if q is known. q will depend on the infiltration discharge into the ground, which should be removed by the drains. Different values have been suggested. Generally, a value equal to 1% of the average annual rainfall of a place is considered to be drained by the tile drains in 24 hours. If the average annual rainfall of the place is P_{AA} (metres), then

$$q = \left(\frac{0.01 \times P_{AA}}{24 \times 3600}\right)(S \times 1) \text{ cumecs/m length of drains}$$

$$= \frac{0.01 \times P_{AA}\cdot S}{24 \times 3600} = \frac{P_{AA}\cdot S}{86{,}40{,}000} = \frac{P_{AA}\cdot S}{8.64 \times 10^6} \qquad \text{...(6.11)}$$

Equating with equation (6.9), we get

$$q = \frac{4K\cdot(b^2 - a^2)}{S} = \frac{P_{AA}\cdot S}{8.64 \times 10^6}$$

or

$$S = \sqrt{\frac{(8.64 \times 10^6)\,4K\cdot(b^2 - a^2)}{P_{AA}}} \qquad \text{...(6.12)}$$

Hence, spacing (S) can be determined easily by using eq. (6.12).

- Drainage coefficient(DC):

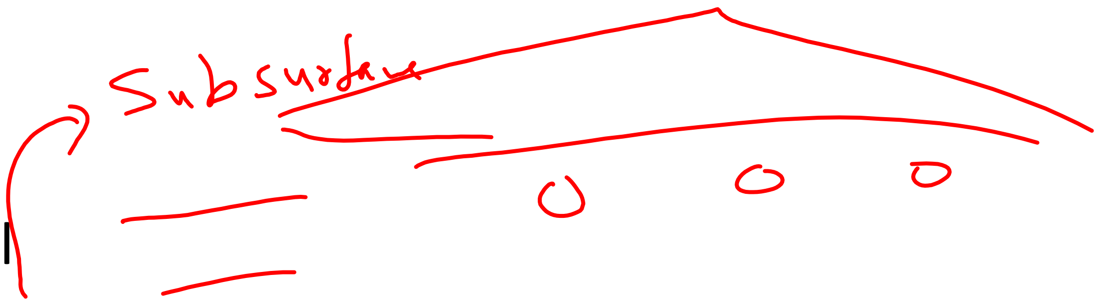
The rate at which water is removed by the drain is called the drainage coefficient. It is expressed by depth of water in 'cm' or 'm' to be removed in 24 hours from the drainage area.

Size of drains:

The drains are designed using Manning's formula to carry the drainage discharge. Slope of drain is usually 0.5 to 3%

10 to 15 cm diameter drains are usually used.

Numerical

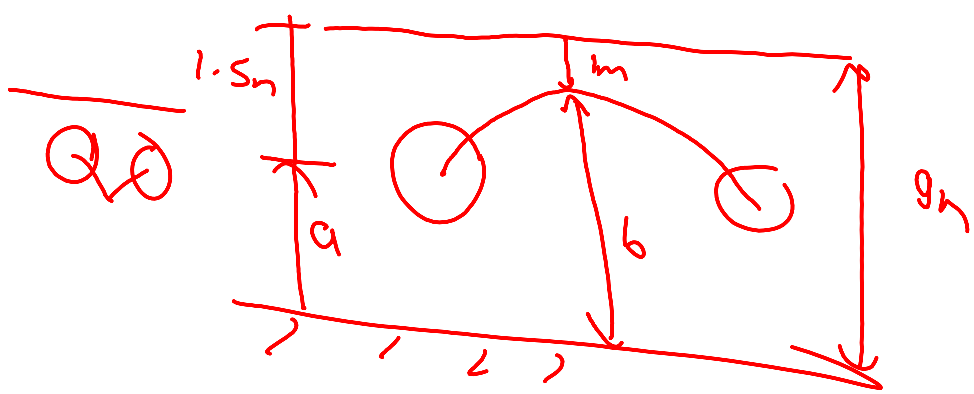


1) A tile drainage system draining 12 hectares flows at design capacity for 2 days, following a storm. If the system is designed using DC of 1.25 cm, how may cubic meter of water will be removed during this period?

$2 \times 1.25 = 2.5\ cm$ $\quad V = \frac{2.5}{100} \times 12 \times 10^4 = 3000\ m^3$

2) In a tile drainage system, the drains are laid with their centers 1.5 m below the ground level. The impervious layer is 9m below the ground level and the average annual rainfall in the area is 80 cm. If 1% of the annual rainfall is to be drained in 24 hrs to keep the highest position of water table to 1m below ground level, determine the spacing of the drain pipes. Coefficient of permeability is 0.001 cm/sec.

$q = \frac{0.01 \times 0.8 \times S}{24 \times 60 \times 60}$



$a = 9 - 1.5 = 7.5$

$b = 9 - 1 = 8$

$K = 0.00001\ m/s$

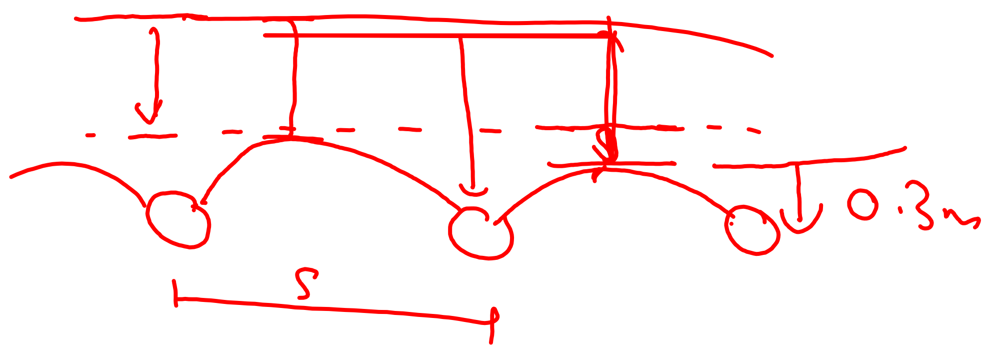
$S = \frac{4K(b^2 - a^2)}{q}$

Sub-surface drainage system and their design

Sub surface drainage is obtained by reducing the ground water table by constructing structures underground. Tile drains are widely used.

<u>Advantages</u>

- Reduction in water logging
- Removes the gravity free water
- Increases air circulation
- Increases bacterial activity
- Reduces soil erosion



<u>Depth of tile drains</u>

- The drains are spaced in such a distance as to be capable of lowering the water table sufficiently below the root zone of the plant
- For most plants the top point of WT must be at least 1.0 to 1.5m below the GL
- The tile drains is placed at 0.3m below the desired highest level of WT

Causes, effects and preventive measures of water logging

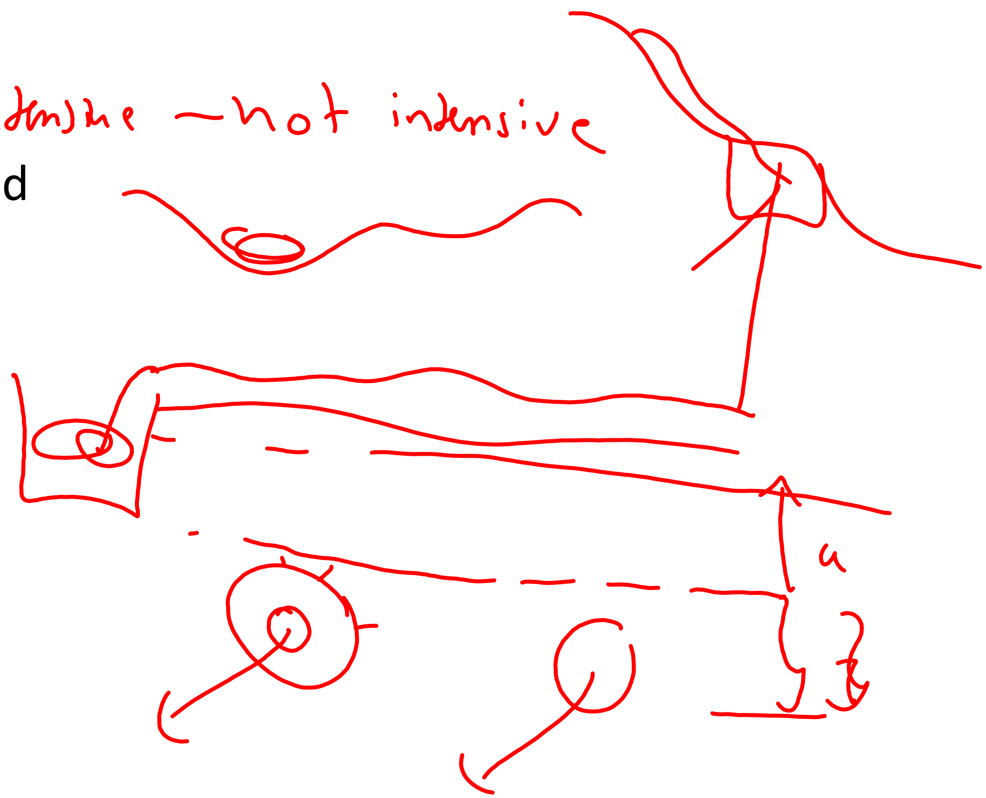
An agricultural field is said to be water logged if its productivity decreases due to rise in the water table and water remains in the field for long period of time. Since, the root zone of the plant remains flooded for longer period of time plant dies due to poor aeration of the root zone.

Causes of water logging

- Over and intensive irrigation

/extensive – not intensive

- Seepage of water from adjoining high land
- Seepage of water through the canal
- Impervious obstruction
- Inadequate natural drainage
- Inadequate surface drainage
- Excessive rain
- Submergence due to flood
- Irregular or flat topography



Effects of water logging

- Normal cultivation operations like tilling and ploughing becomes very difficult.
- Water loving plants grow profusely in water logged areas interfering growth of crops. (growth of unwanted plants like water hyacinth and water weeds)
- Water logging also leads to **salinity**.
- Restricted root growth
- Reduced soil temperature

Preventive measures of water logging:

A) Reduce percolation from irrigation canals

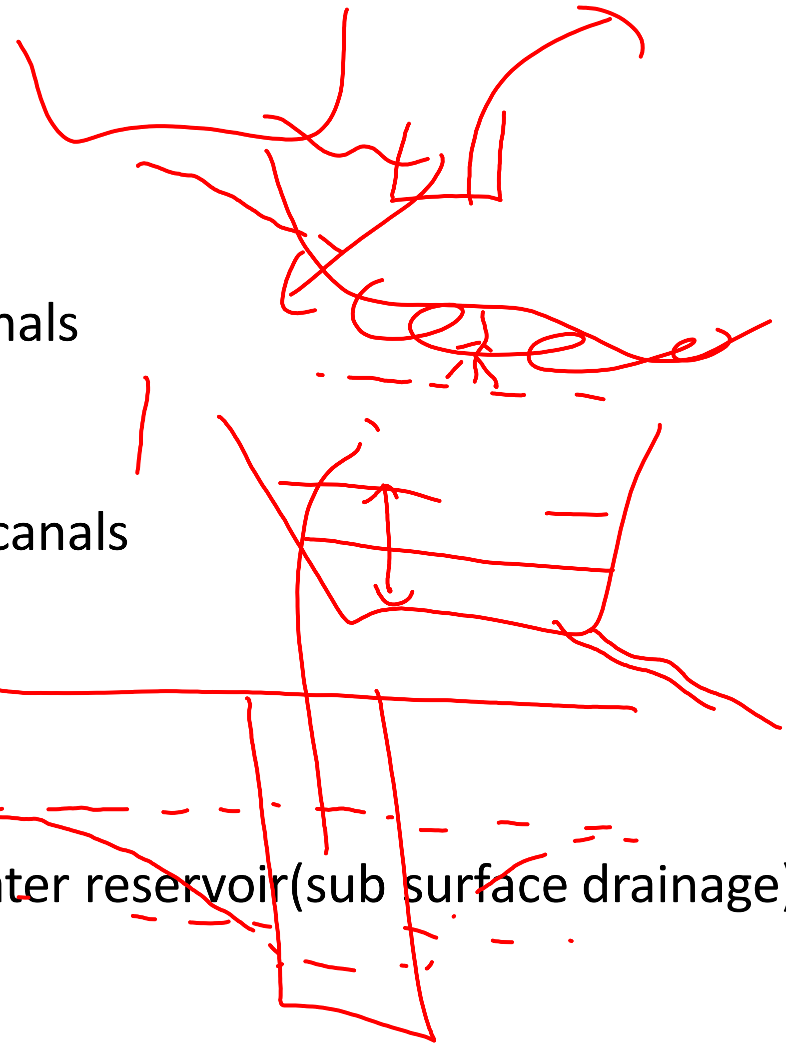
- Lining of canals
- Lowering of FSL of the canal
- Providing intercepting drains along the canals

B) Encouraging economical use of water

- Educating cultivators
- Changing crop pattern
- Changing revenue policy

C) Increasing outflow from the ground water reservoir(sub surface drainage)

- Providing subsurface drainage system
- Improving natural drainage of the area
- Regular pumping of the groundwater



Methods of reclaiming water logged land

1. Proper Drainage System

Farmers should have adequate surface drainage facilities to remove excess water from their fields. The surface runoff and subsoil drainage of water should not be so slow. During rainy season efforts should be made not to retain water on soil surface.

2. Using Tube Wells

A tube well is an ideal device to lower the level of water in water logged areas. Tube wells have the capability to draw out of the earth large quantities of water continuously. It is a good technique to reclaim water logged areas by installing tube wells.

3. Lining of Canals

In order to minimize water logging, concrete lining of canals and other water channels should be done. It will be helpful not only in controlling water logging but also in saving useful irrigation water.

- **4. Water Management**

  Farmers should be educated about water management. Use of excessive irrigation water for cultivation of certain crops should be avoided. Modern irrigation techniques like drip irrigation should be adopted.

  5. Tolerant Crops

  Crops like rice, oats, etc should be preferred in water logged areas. Because rice require more moisture for its growth.

  6. Tolerant Trees

  Trees like Eucalyptus, willows, etc should be planted in water logged areas because of its high moisture requirement

Salinity of soil

The process of increasing the salt concentration of soil is called as salinity of soil.

The harmful salts are:

a)Sodium carbonate

High concentration and very harmful.

Also called as black alkali

SAR

a)Sodium chloride

b)Sodium sulphate

•Maximum permissible salt concentration for crop production is 3000 ppm

Effloresence

•The formation of white patches on ground surface after evaporation of water form water containing salts that comes up during water logging is called as efflorescence.

Reclamation of soil: It is the process by which an unfit land is made fit for cultivation.

Leaching: It is the process by which the soil is made free from salts by washing it off with water. Generally gypsum is added in leaching water.

Generally gypsum ($CaSO_4$) is added as soil amendment for alkaline soil.

Limestone ($CaCO_3$) is added as soil amendment for acidic soil.

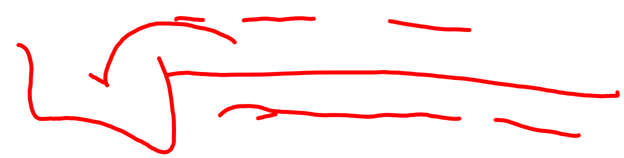
6.5 - 8.5 ph

Drainage of irrigated land

- Removal or control of excess water either on the surface soil or in the root zone beneath the soil is called drainage.
- <u>Necessity of drainage</u>

❑ Removal of excess irrigated water

❑ Drain out storm water effectively and prevent percolation



<u>Types of drainage system</u>

Surface drainage

Shallow drainage and deep drainage

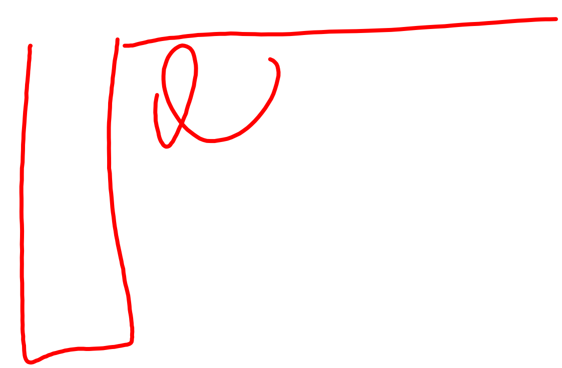
Sub-surface drainage

Surface drainage systems and their design

- Surface drainage is the process of removal of excess rainwater falling on the fields or excess irrigated water by constructing open ditches, field drains and other structures.

<u>Shallow water drain</u>

- Designed to remove excess irrigated water and rainfall.
- Normally trapezoidal in shape
- Manning's and chezzy's equation is used to design

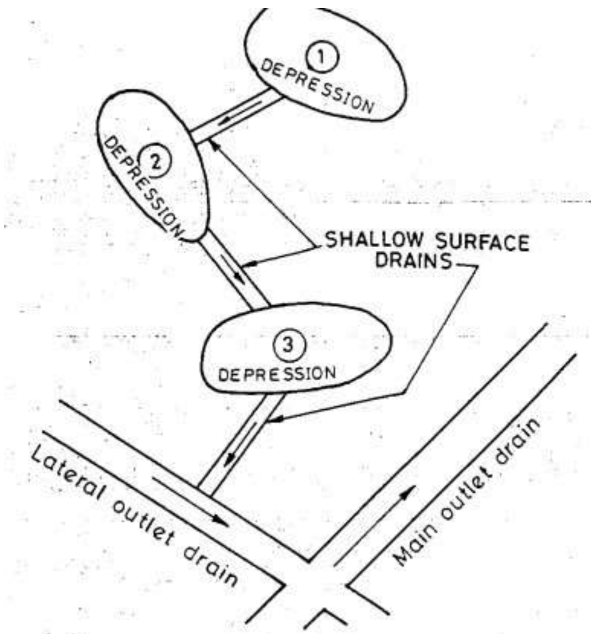


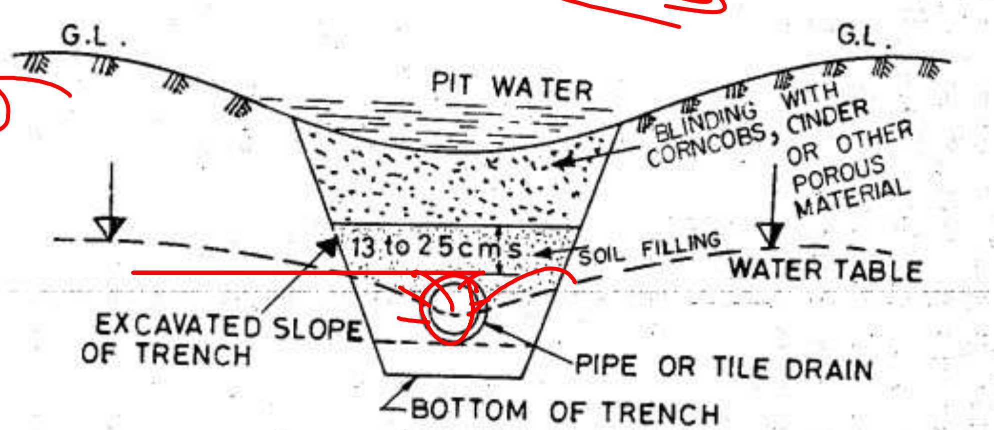
<u>Deep water drain</u>

Dug up to the level of ground water table.

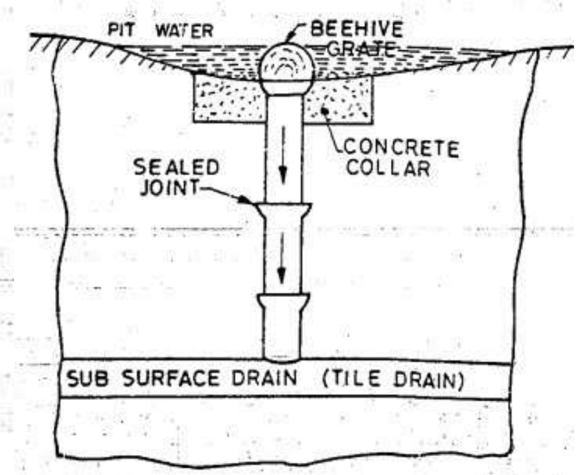
Methods of surface drainage:

1) Shallow surface drain
2) Deep surface drain or outlet drain
3) French drain
4) Surface inlet
5) Bedding





French drain

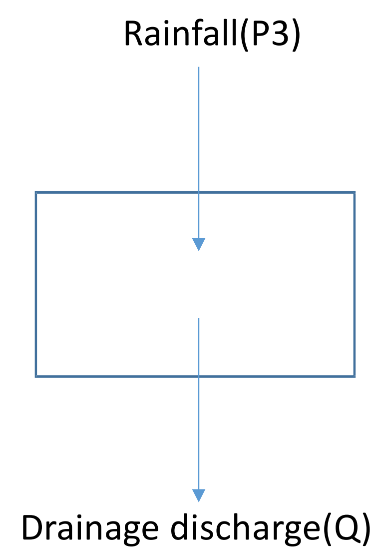


Design consideration of surface drainage

There are different assumptions in designing the drainage system in Terai and Hilly region. There assumptions are useful in determining the required drainage discharge.

Assumptions in Terai Region:

- Rainfall with return period of 5 to 10 years should be considered.
- Initial water level in the field = 40mm
- Maximum allowable water level = 300mm which remains for 24 hours
- Depth in excess of 200mm may remain for 3 days
- Evaporation and transpiration is neglected
- Irrigation inflows are neglected.
- P3=cumulative yearly maximum rainfall for consecutive 3 days.



Applying water balance equation,

$$h = 40 + P_3 * t/3 - Q * t$$

Q= outflow flow discharge in mm/day General form of eqn:

$$h = h_i + P_3 * t/3 - Q * t$$

Where, hi= initial depth of water in the field

P3=consecutive 3 days cumulative rainfall

t= no. of days under consideration

Design the capacity of surface drainage of Terai region for the field having rainfall intensity of P3=450 mm, area of the field is 30 ha.

Solution

First trial $Q = 60$ mm/day

$h = 40 + \frac{P}{3} \times t - Q \times t$. } 3 day }

Day	Initial depth	P/3	Q	Final water depth (h)
1	40	150	50	140 = 40 + 150×1 − 50×1
2	140	150	50	240
3	240	150	50	340

40 + 150t − 65t

Since water depth > 300 mm ; Q is insufficient

∴ 2nd trial is required.

130
220
310 ×
350
190

Second trial $Q = 75$ mm/day.

Day	Initial depth	P/3	Q	Final water depth (h)
1	40	150	75	115
2	115	150	75	190
3	190	150	75	265
4	265	~~150~~	75	190
5	190	−	75	115

125
210
295
230
165

For this trial water depth is never greater than 300.

Depth excess of 200 mm remains for one day.

But we can have depth > 200 mm for 3 days.

Hence, above design may be uneconomical.

Hence, go for 3rd trial.

Third trial, $Q = 65$ mm/day.

Day	Initial depth	P/3	Q	Final water depth (h)
1	40	150	65	125
2	125	150	65	210
3	210	150	65	295
4	295	−	65	230
5	230	−	65	165

Area = 30 ha.

$Q = A \times q'$ (mm/day)

$\therefore Q = \frac{65 \times 30 \times 10^4}{1000 \times 24 \times 60 \times 60} = 0.226\ m^3/sec.$ (m^3/sec, m/sec)

Hence, the surface drainage discharge should be $0.226\ m^3/sec$.

Now, the surface drainage system should be designed for the capacity of 0.226 m^3/s

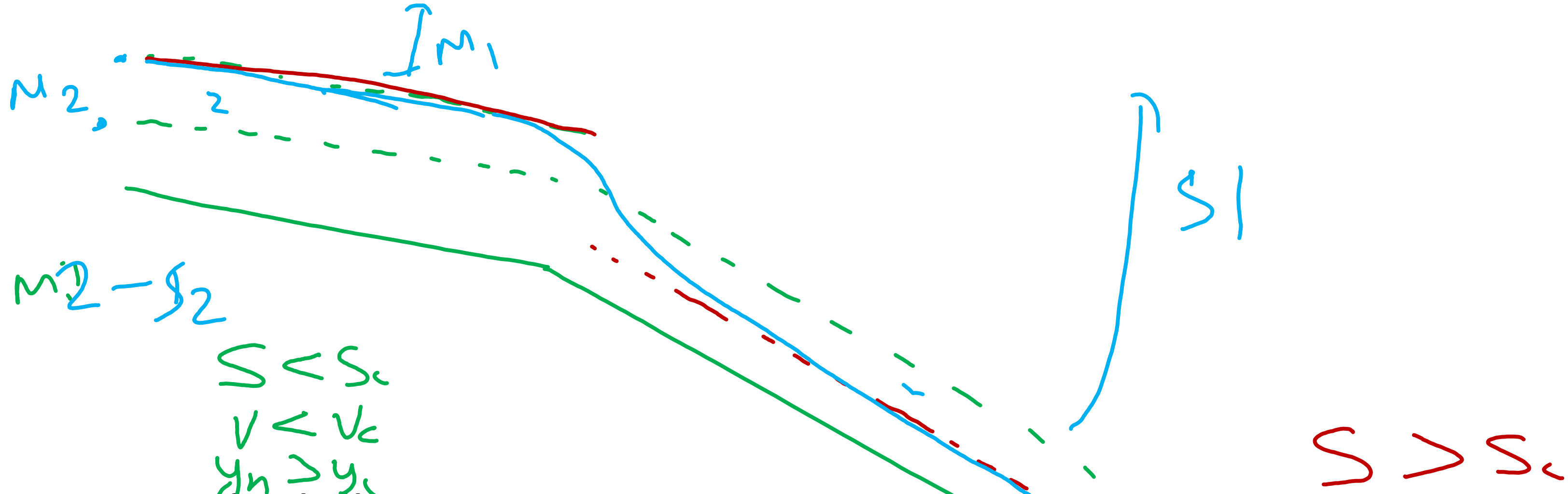
$40 + 150 \times t - 70 \times t$

$40 + 80t$

a) 60 mm/d
b) 65
c) 70
d) 180

1) 120
2) 200
3) 280
4) 210

190



Assumptions for hilly region:

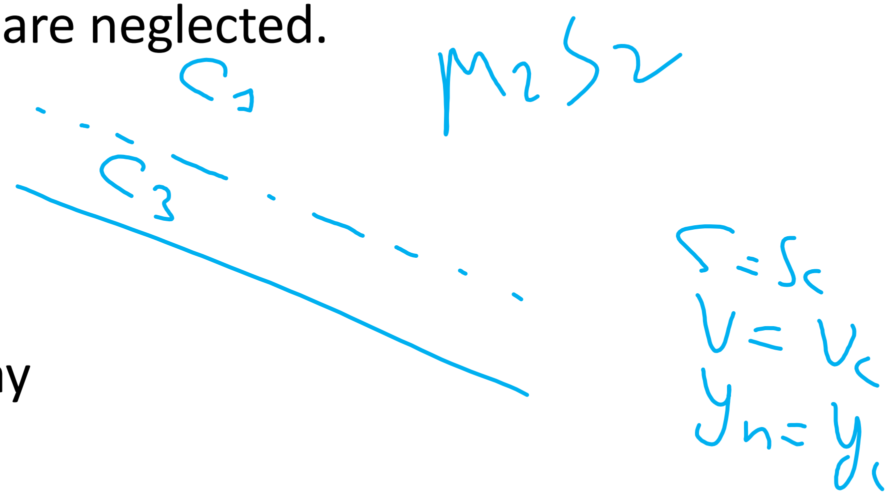
- Rainfall with return period of 5 to 10 years is considered.
- Initial water level in the field = 40mm
- Maximum of 100 mm depth of water is allowed for 1 day
- Evaporation and transpiration loss are neglected.
- Irrigation flows are neglected

Equation used is:

h=40 + P –Q

Where, P=yearly maximum rainfall

Q=drainage discharge rate in mm/day



If $P = 150$ mm/day

$Q = 40 + P - h$

$= 40 + 150 - 100 = 90$ mm/day