9th Sept,
TUESDAY

9. SEEPAGE ANALYSIS

* Flow Line or Stream line.

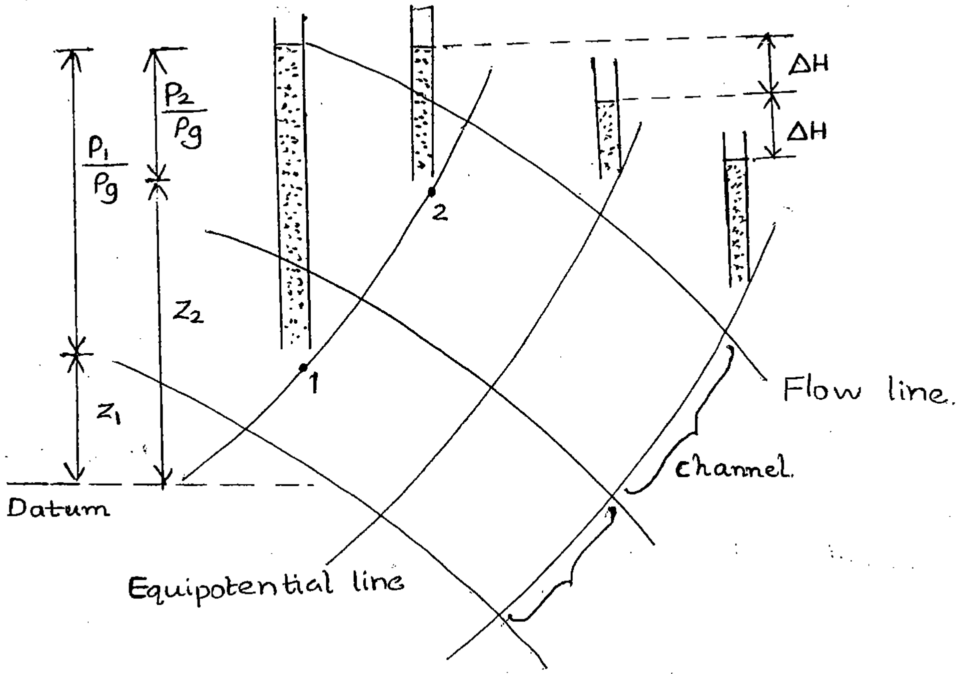
Line which shows the direction of seepage on flow.

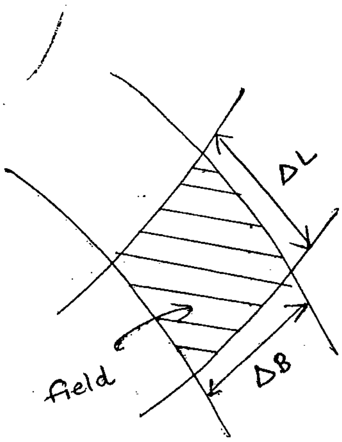
* Equipotential Line

Total Head or potential remains the same at all points in an equipotential line.

* Flow net

Network of equipotential lines and flow line.





(i) Total head remains the same at all points in an equipotential line.

(ii) Head loss remains the same b/w two adjacent ~~flow~~ equipotential line. (ΔH is same)

(iii) ΔQ remains the same for channel.

(iv) For every field, $\frac{\Delta L}{\Delta B}$ ratio must be same.

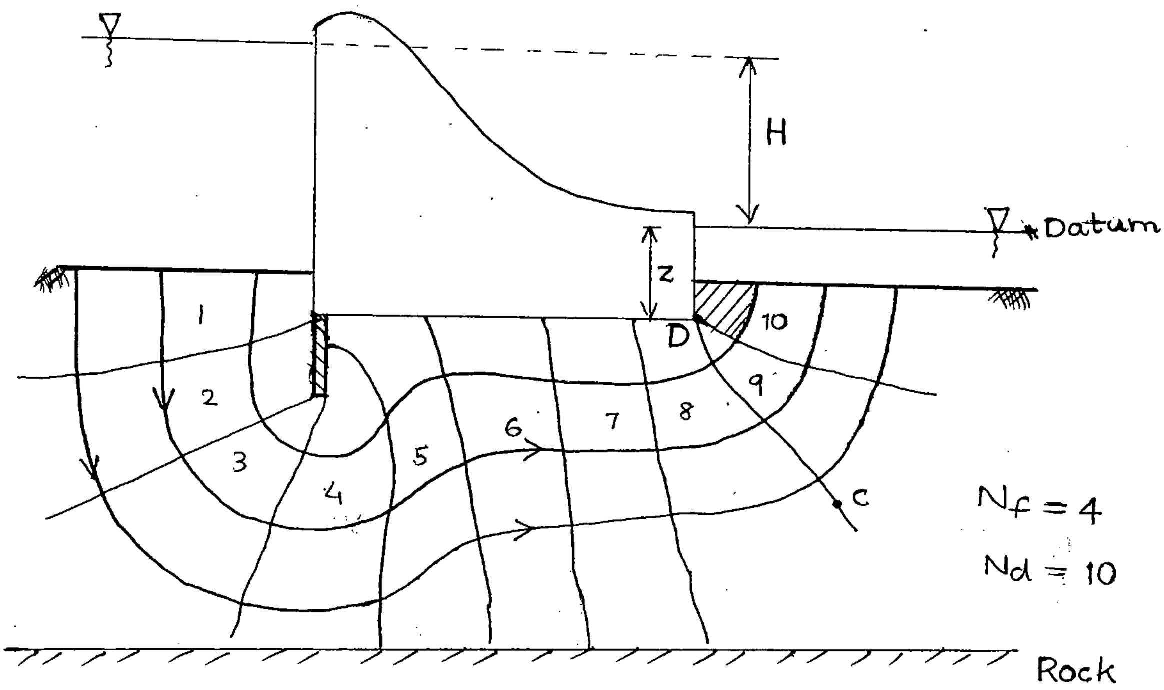
* Applications of Flownet.

(i) To find seepage loss rate.

(ii) To find seepage pressure.

(iii) To find uplift pressure.

(iv) To find exit gradient



H = seepage head (or) head causing flow. (or) total head loss

(i) Seepage Loss Rate, Q

important

$$\boxed{\begin{aligned} Q &= kH\frac{N_f}{N_d}\left(\frac{\Delta B}{\Delta L}\right) \quad ; \text{ for rectangular fields} \\ &= kH\cdot\frac{N_f}{N_d} \quad ; \text{ for square fields.} \end{aligned}}$$

$N_f \rightarrow$ No: of flow channels.

$N_d \rightarrow$ No: of potential drops.

$\frac{N_f}{N_d}$ = shape factor of flow net (a constant)

(ii) Seepage Pressure, P_s

$$\boxed{P_s = \gamma_w h}$$

$h \rightarrow$ balance seepage ~~heath~~ head at point C.

h = total seepage head − head loss upto point C.

$= H - h_f$.

$h_f = n\,\Delta H$; $n \rightarrow$ no: of potential drops upto C.

$\Delta H \rightarrow$ head loss b/w two adjacent equipotential lines.

$$\Delta H = \frac{H}{N_d} \Rightarrow h = H - \frac{nH}{N_d}$$

(iii) Uplift Pressure, P_u

$$\boxed{P_u = \gamma_w h_w}$$

$h_w \rightarrow$ pressure head at point D.

Total head = Pressure head + Elevation head.

$$h = h_w + z$$

$$h_w = h - (-z)$$

$$h_w = h + z$$

(iv) Exit Gradient, i_{exit}

$$\boxed{i_{exit} = \frac{\Delta H}{\Delta L}}$$

$\Delta L \rightarrow$ length of field at exit. (hatched field)

A flow net is shown in the fig. If coefficient of permeability of soil is 2×10^{-3} cm/s, determine the seepage loss rate in m³/day per m length of the weir.

$N_f = 4$ $\quad H = 10.5 - 0.5 = 10$ m, $z = 0.5 + 0.8 = 1.3$ m

$N_d = 14$ $\quad K = 2 \times 10^{-3}$ cm/s, $\quad \Delta L = 1.2$ m.

Determine the seepage pressure and uplift pressure at point D shown in the fig, take depth of foundation as 0.8 m. Also determine the exit gradient if length of the field at the exit point is 1.2 m.

$$\left.\begin{matrix}\text{Seepage} \\ \text{loss rate}\end{matrix}\right\}, \quad Q = KH \frac{N_f}{N_d}.$$

$$= 2 \times 10^{-3} \times 10^{-2} \times 10 \times \frac{4}{14} \times 60 \times 60 \times 24.$$

$$K = \underline{\underline{1.728}} \ m/day \quad \& \quad Q = 4.937 \ m^3/day.m$$

$$\text{Seepage pressure, } P_s = \gamma_w h.$$

$$= \gamma_w \left(H - \frac{nH}{N_d}\right)$$

$$= 10\left(10 - \frac{9 \times 10}{14}\right) = \underline{\underline{35.714}} \ kPa$$

$$\text{Uplift pressure, } P_u = \gamma_w h_w$$

$$= \gamma_w (h+z).$$

$$= 10(3.5714 + 1.3) = \underline{\underline{48.714}} \ kPa$$

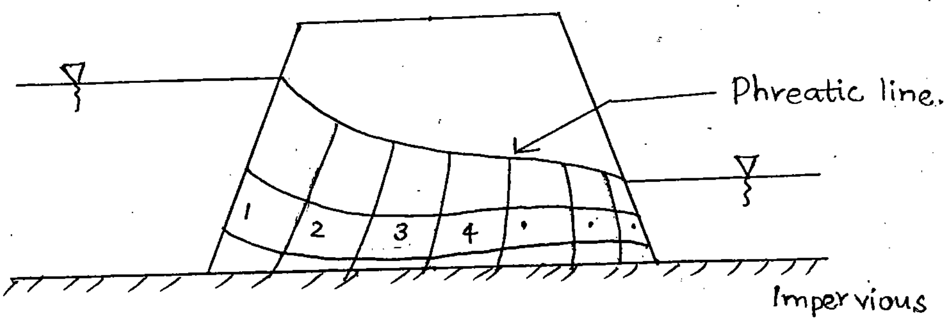
$$\text{Exit gradient; } i_{exit} = \frac{\Delta H}{\Delta L} = \frac{10/14}{1.2} = 0.595 \ m.$$

→ Earthen Embankment

$N_f = 3$

$N_d = 7$

$$Q = KH \frac{N_f}{N_d}.$$



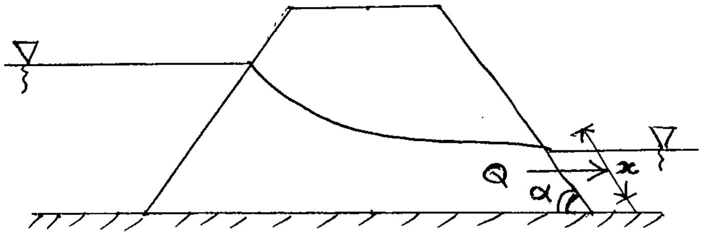
* Phreatic Line:
  - topmost flow line
  - On the phreatic line, pressure head is zero.
  - Parabolic shape

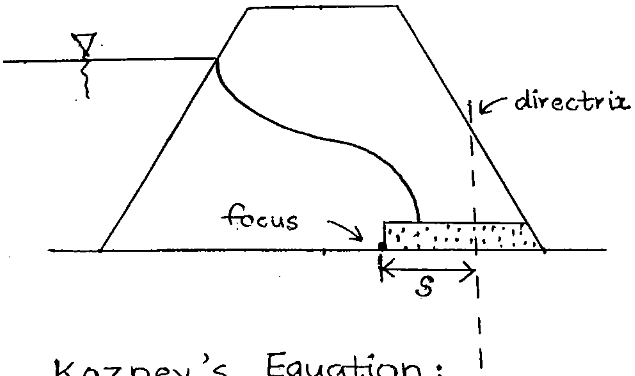
- If $\alpha < 30^\circ$,

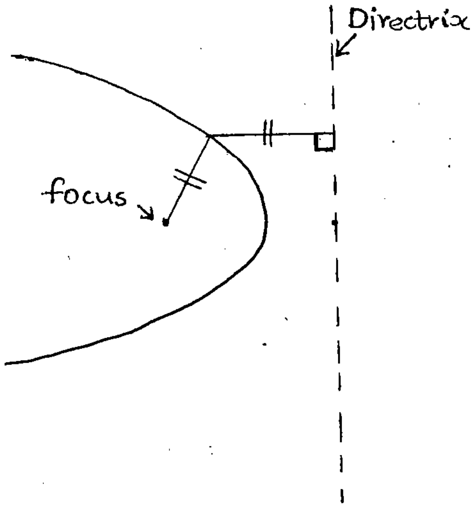
$$Q = k.x.\sin\alpha.\tan\alpha$$

If $30^\circ \leq \alpha \leq 60^\circ$,

$$Q = k.x.\sin^2\alpha$$





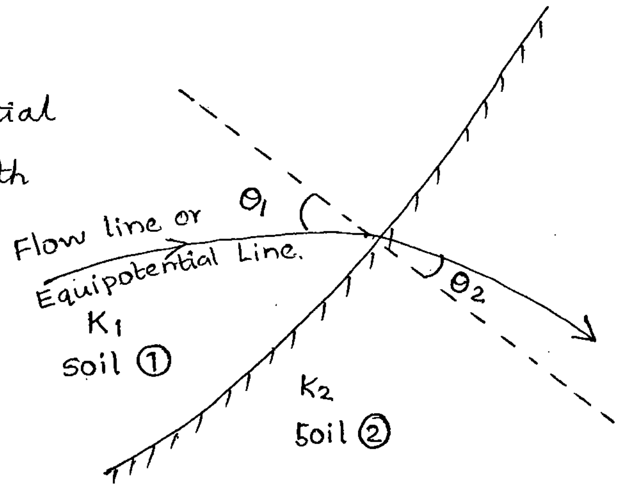


Kozney's Equation:

$$Q = K.S.$$

→ Anisotropic Soil:

Flow lines or equipotential lines are generally smooth lines. But whenever permeability changes, there will be deflection.



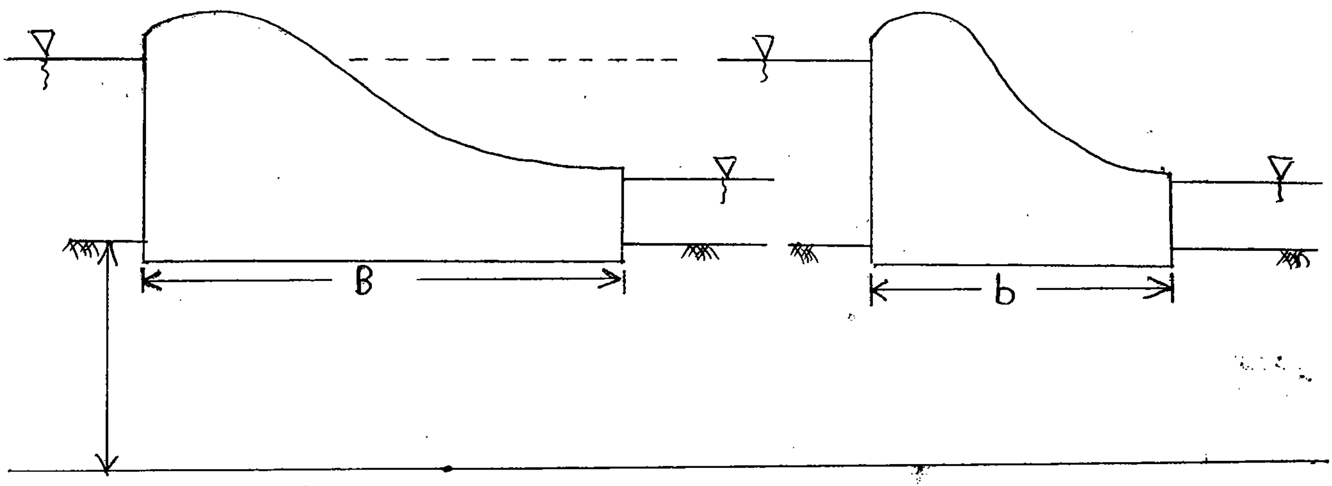
$$\boxed{\frac{\tan\theta_1}{\tan\theta_2} = \frac{k_1}{k_2}.}$$

In the case of anisotropic soils ($k_x > k_y$), the flow net is to be drawn to the transformed section which is obtained by reducing the horizontal dimensions and keeping vertical dimensions unchanged. The horizontal dimension is reduced by multiplying with a reduction coeffecient of

$\sqrt{\dfrac{k_y}{k_x}}$. The seepage loss rate is computed by taking average permeability (k') as follows:

$$Q = k' H \frac{N_f}{N_d}.$$

where $k' = \sqrt{k_x . k_y}$



1. $b = B \sqrt{\dfrac{k_y}{k_x}} = 65.8 \text{ m}.$

Scale factor $= 1:25$

$$= \frac{65.8}{25} = \underline{\underline{2,63 \text{ m}}}$$

2. $\underset{(cm/s)}{K} = 100 \underset{(cm)}{D_{10}^2} = 100 \times (0.01)^2 = 10^{-4} \text{ cm/s} = 10^{-6} \text{ m/s}$

$$Q = kH. \frac{N_f}{N_d} = \underline{\underline{1.5 \times 10^{-4}}} \text{ m}^3/\text{s} \text{ per metre length}$$

3. $K = 3.8 \times 10^{-6}$; $H = 6.3$ m ; $N_f = 3$; $N_d = 10$

$$Q = KH \frac{N_f}{N_d} = 7.18 \times 10^{-6} \text{ m}^3/\text{s per m length}$$

$$= 7.18 \times 10^{-6} \times 10^{6} \text{ cm}^3/\text{s per m length}$$

$$= \underline{\underline{7.18}} \text{ cm}^3/\text{s}$$

4. $\Delta H = \frac{H}{N_d} = \frac{18}{9} = 2\,m$

$n = 3.$

$\therefore h_f = n\,\Delta H = 6\,m$

$h = H - h_f = 18 - 6 = \underline{\underline{12\,m}}$