EWCE 341: Principles of Soil Mechanics

Seepage Analysis

What we are going to discuss today:

- What is seepage?
- Importance of Seepage Flow
- Flow line, Equipotential line, Flow net, Flow channel
- Study from the flow net
- Basic Flow net construction –Vertical Flow
- Properties of Flow net
- Example of flow net below sheet pile

What is Seepage?

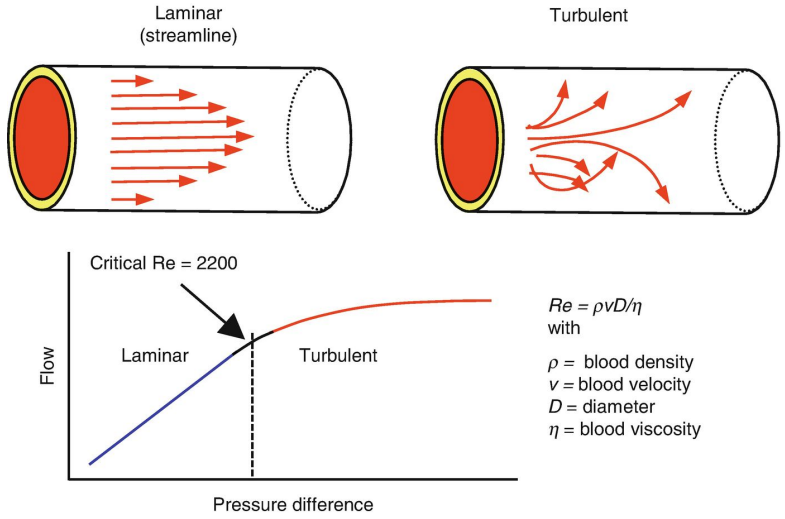
Seepage Analysis

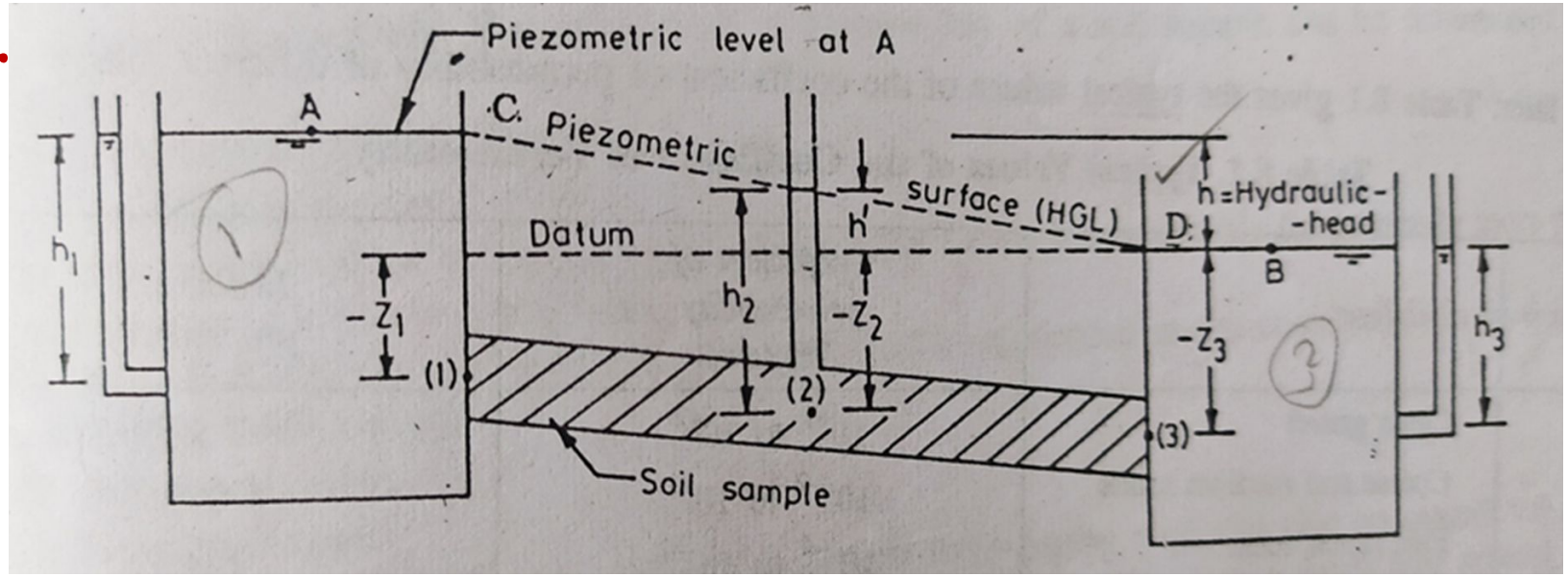
What is seepage?

- Seepage is the **flow (slow escape) of water under gravitational forces** in **permeable medium (soil).**

- **Flow of water takes place** from a point of **high head** to a point of **low head**.

- Flow is generally **laminar**



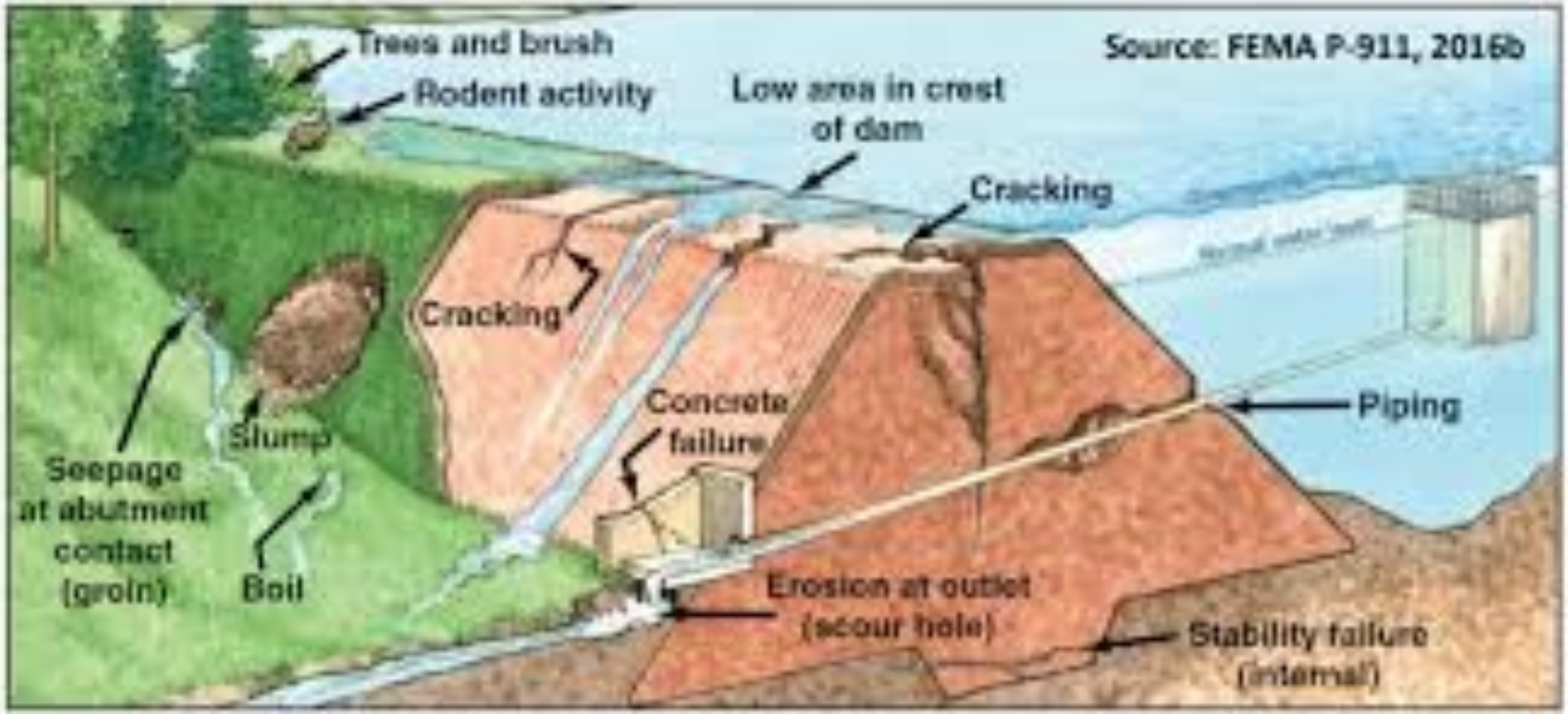


Importance of Seepage Flow:

Importance of Seepage Flow:

- **Interaction between soils and percolating water** has an important influence on:
  -**Design** of foundations and earth slopes.
  -**Quantity of water** that will be lost by percolation through a dam or subsoil.

- **Foundation failures** due to ***piping*** is quit common.



- **In stability of slopes**, the **seepage force** is an important factor.
- **Shear strength of soils get reduced** due to the development of neutral stress or pressure.

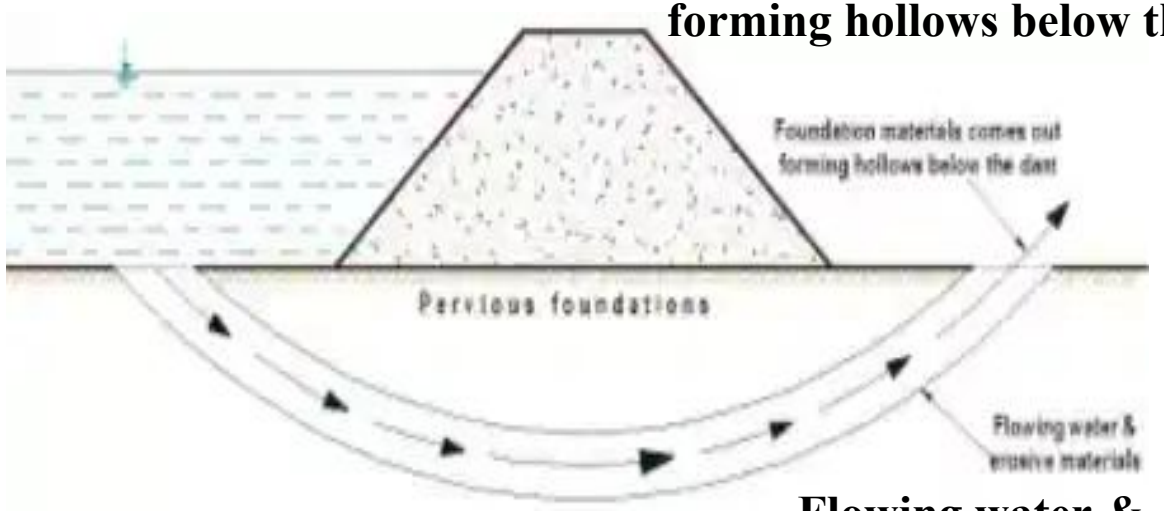
A detailed understanding of **hydraulic conditions** is therefore essential for the satisfactory design of structures.

Piping

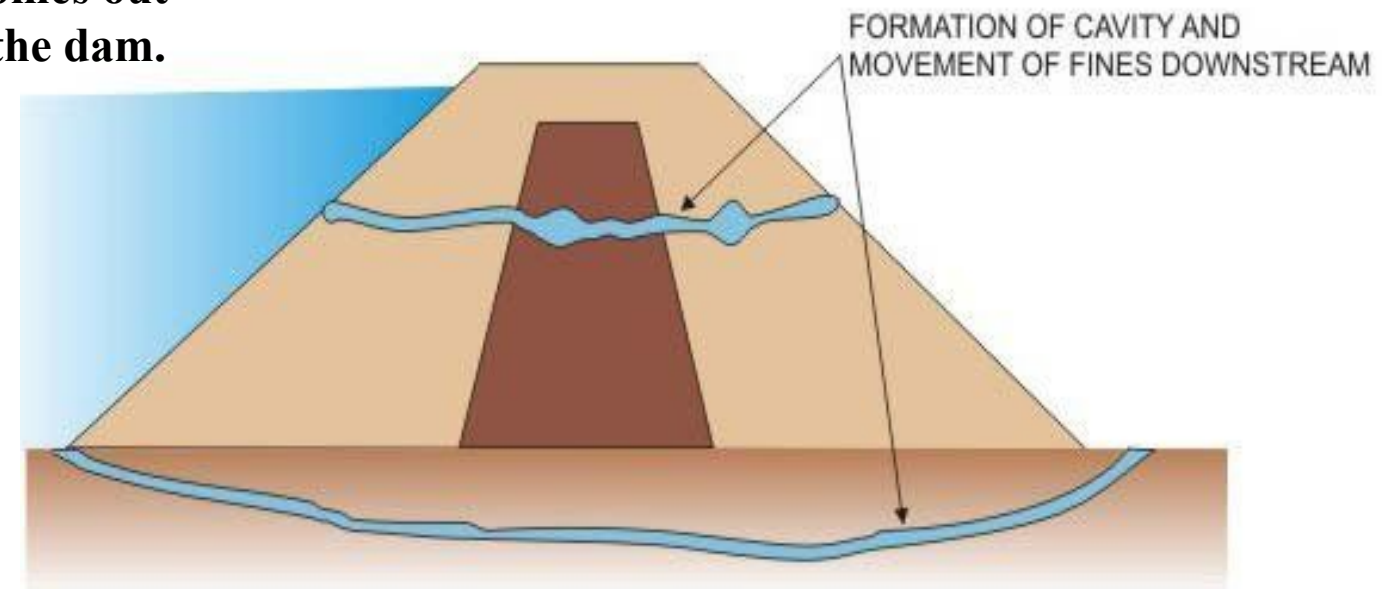
What is piping?

- Progressive development of **internal erosion** by **seepage**, **appearing downstream as a hole discharging water**.
- **Induced by regressive erosion of particles** from downstream and along the upstream line **towards an outside environment** until a continuous pipe is formed.
- **Internal erosion** is the **formation of voids within a soil** caused by the removal of material by seepage.

Foundation materials comes out forming hollows below the dam.



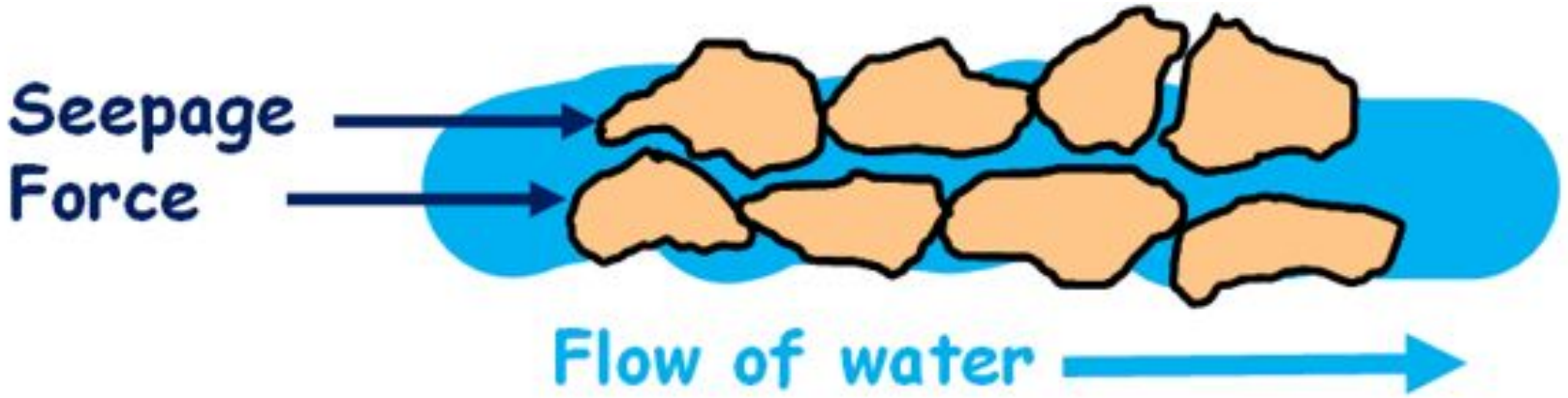
Flowing water & Carries materials



Seepage: Phenomenon of flow of water or movement of water through the **soil** is called **seepage.**

Seepage Force: **Force** applied by the water on the **soil** particles is called the **seepage force.**

Seepage pressure: Because of Force, pressure developed in the **soil** is termed as **seepage** pressure

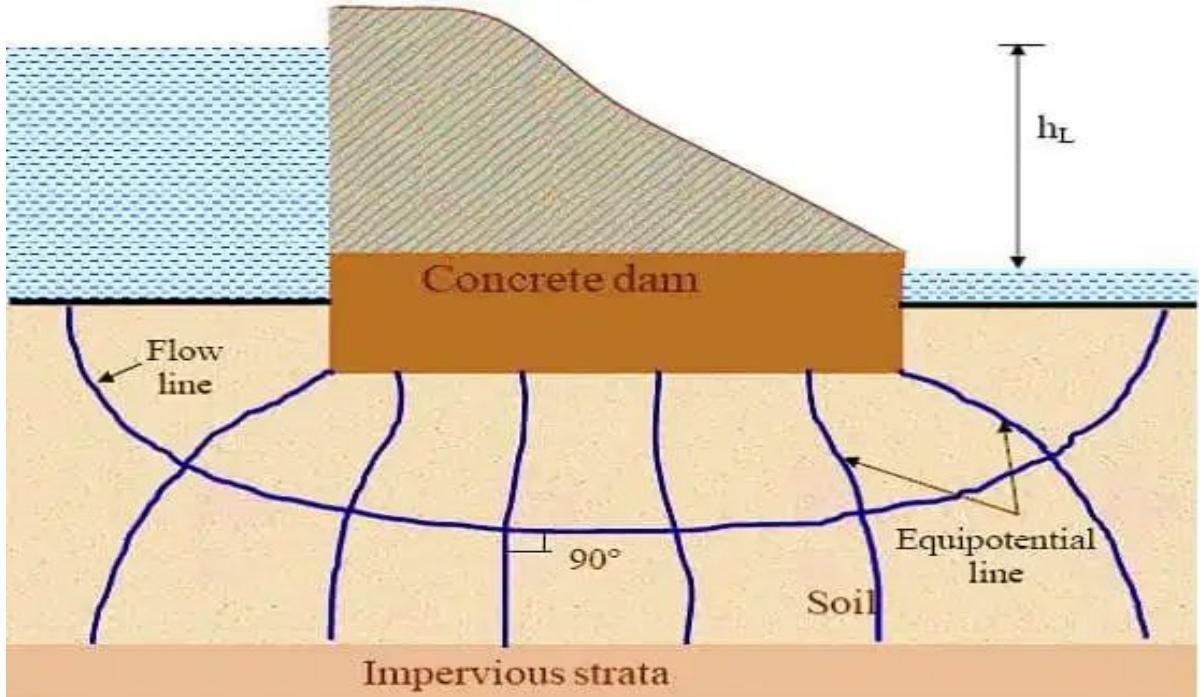


Flow line, Equipotential line, Flow net, Flow channel/tube, Flow element/field

Flow Line:

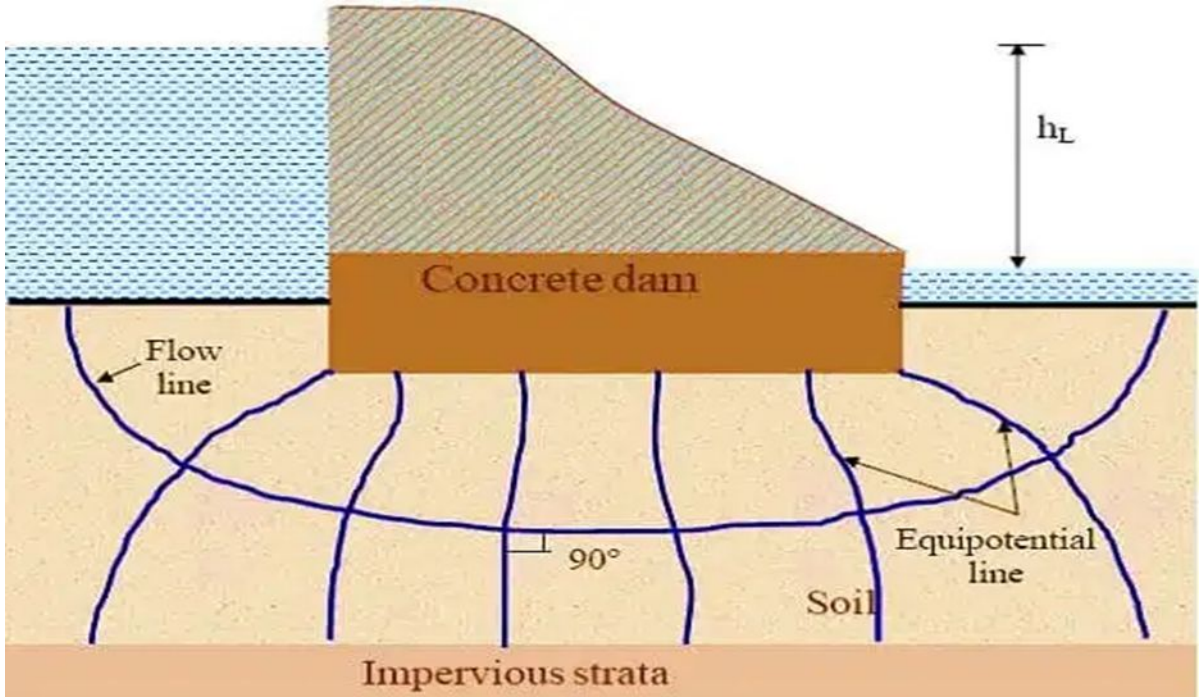
- **Path** which **a particle of water follows** in its course of seepage **through a saturated soil mass** is called a **flow line**.

- Although **an infinite number of flow lines** can be drawn, but for convenience, only a few are drawn.
- **At certain points on different flow lines,** the **total head** will be the same.



Equipotential Line:

- Lines connecting **points of equal head** can be drawn.
- At all points along an equipotential line, water would rise in piezometric tube to a certain elevation known as piezometric level.
- As flow always take place along the steepest hydraulic gradient, **equipotential lines cross flow lines at right angle**.



Flow net:

- **Flow lines** and **equipotential lines** **form a flow net.**
- Gives **pictorial representation** of the **path taken** by water particles and **head variation** along that path.
- Network of flow lines and equipotential lines **intersecting at right angles** to each other.

Path which a particle of water follows in its course of seepage through a saturated soil mass is called a **flow line**.

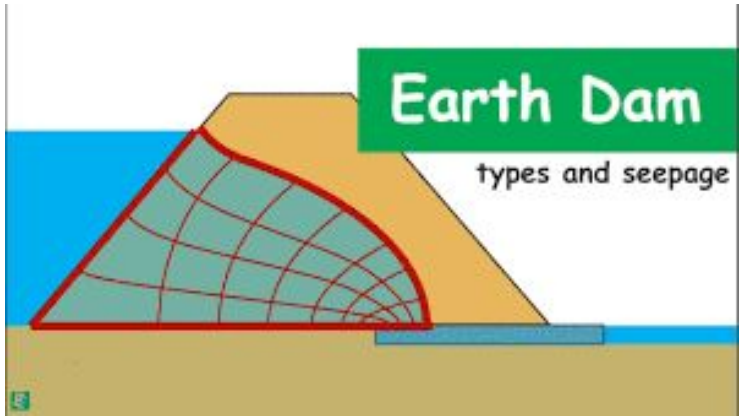
Equipotential lines are lines that intersect the flow lines at **right angles**.

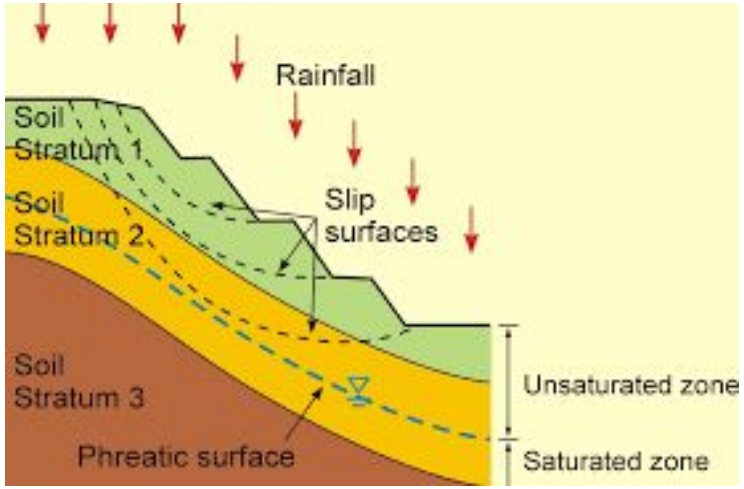
At all points along an equipotential line, the water would rise in piezometric tubes to the same elevation known as the piezometric head .

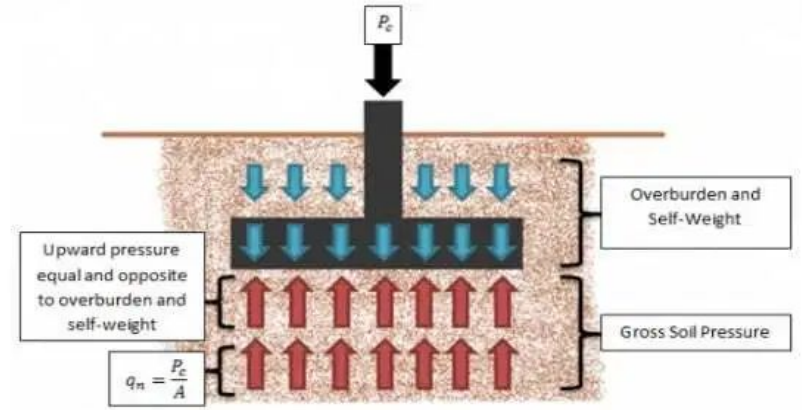
Requirements of Studying Flow net

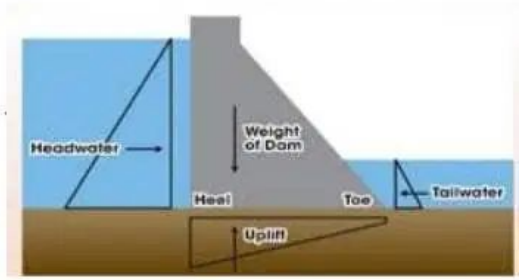
Following can be studied by the construction of Flow Net:

- Computation of **seepage lost** under or through a dam,
- **Estimate of Uplift pressures** caused by the water on the base of a concrete dam and
- **Study of the Effect of seepage** on the stability of earth slopes





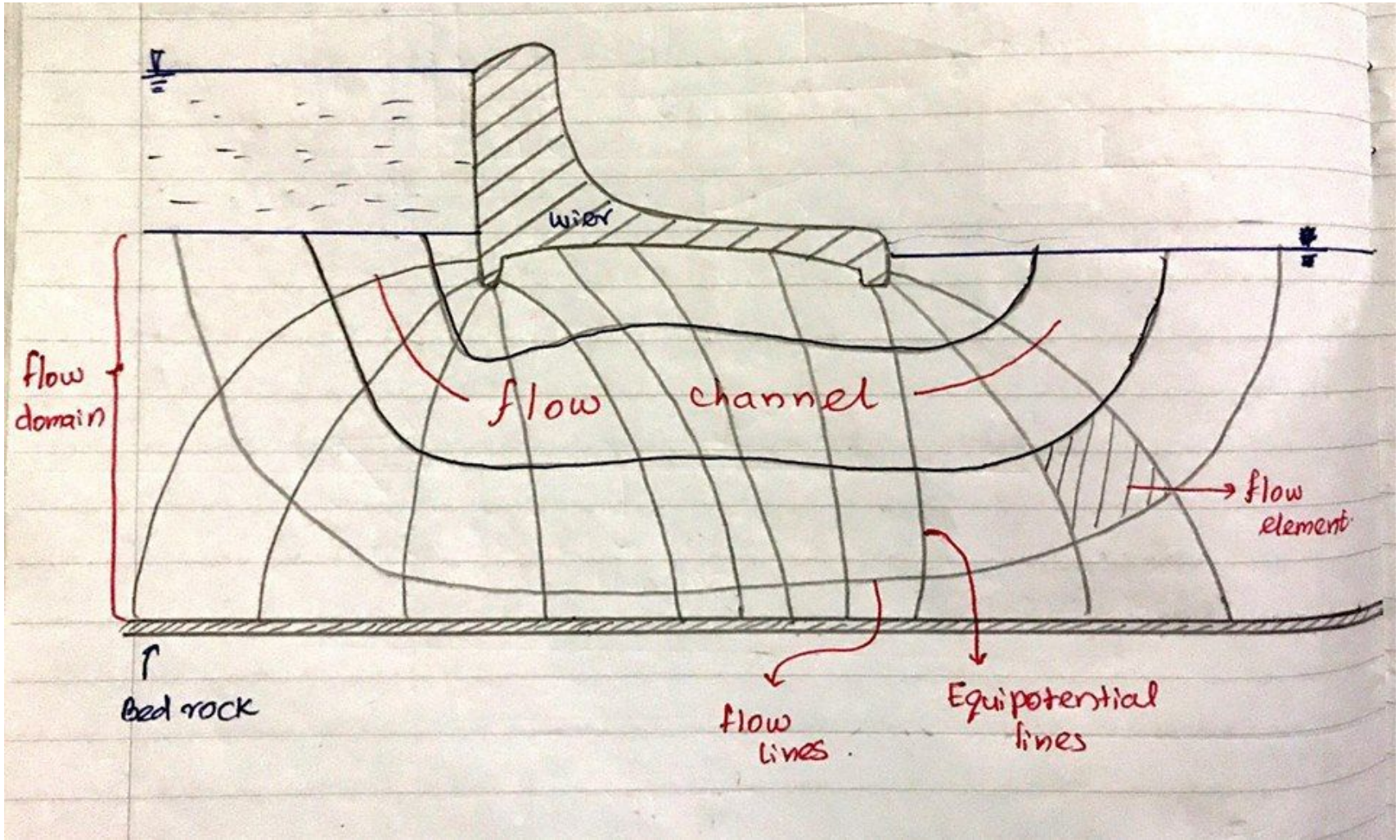




Uplift Pressure- Effects, and Prevention Strategies

Flow Channel:

- A **flow channel** is a **space between two flow lines**.
- **Head lost** is the same between two adjacent potential lines and independent of the permeability and the head causing **flow.**



Weir:

- Basically **an obstruction in the flow path** in open channel.
- Will cause an **increase in water depth** as water flow over the weir.
- The greater the flow rate, the greater will be the increase the depth of flow.

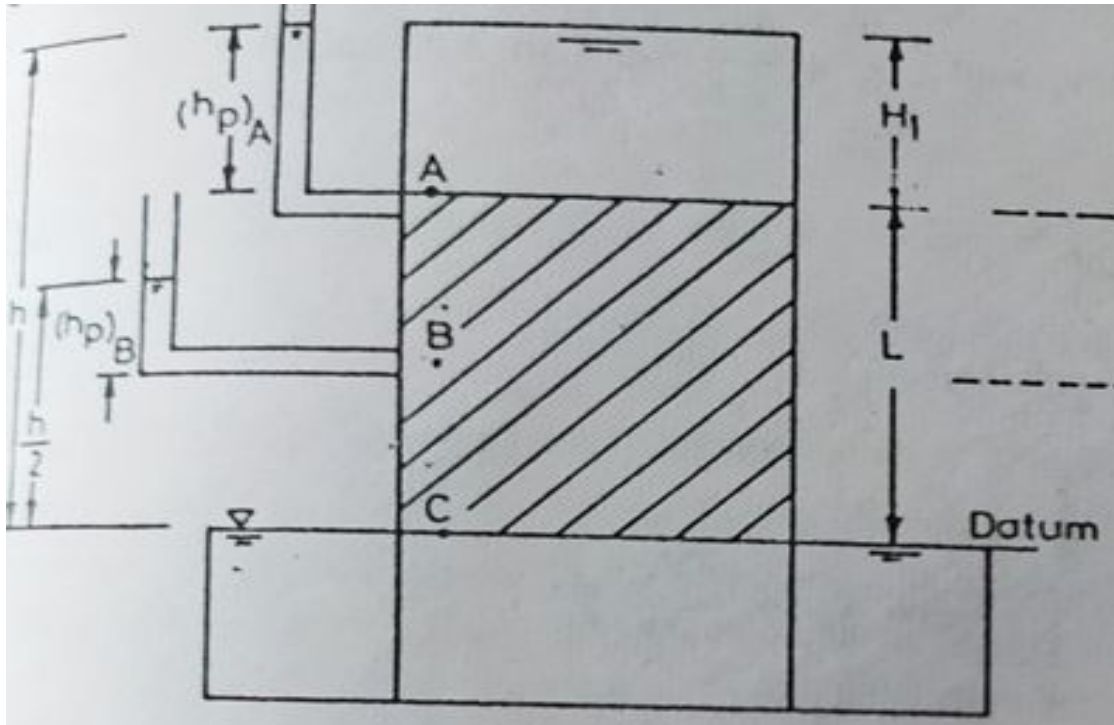


Basic Flow Net Construction -Vertical Flow through soil:

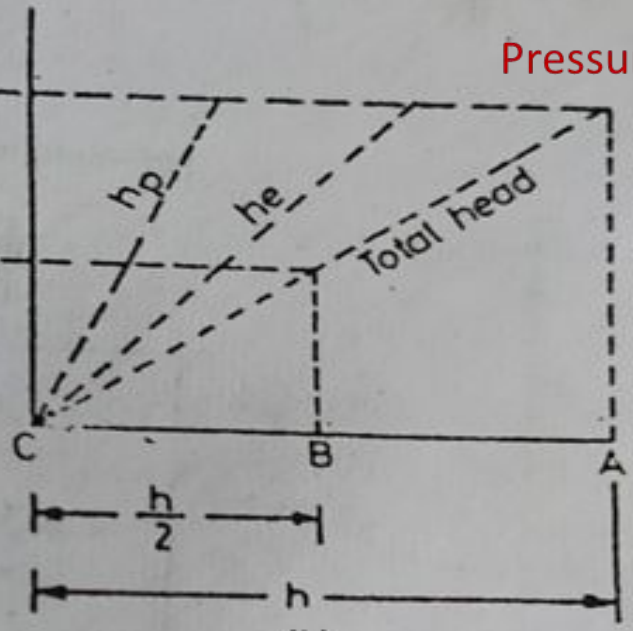
- Figure (a) shows that a **glass cylinder** containing soil sample of length L.
- A **steady flow occurs** vertically downward through the soil sample under a **head h.**
- **Elevation head, pressure head** and **total head** at points at A, B and C can be worked out as shown in Figure (b) and Figure (c).

Elevation Head h_e, *from datum*

Pressure Head h_p, *from piezometer*



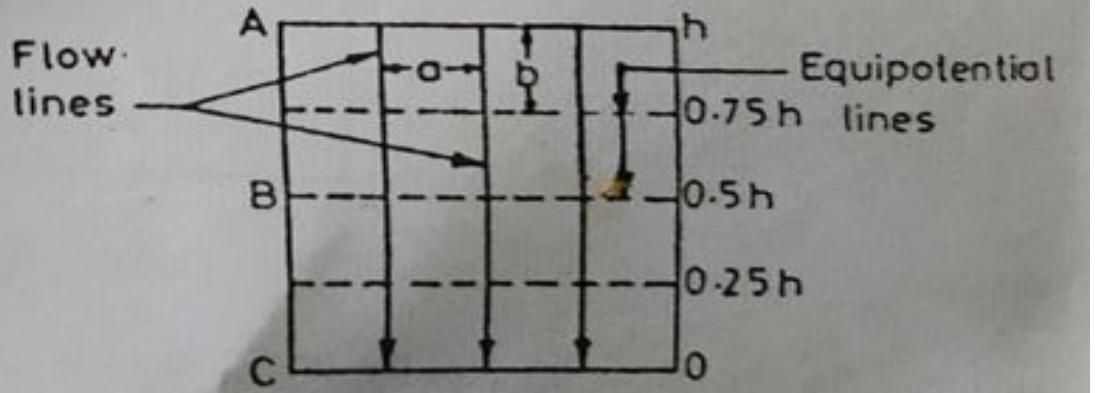
(a)



(b)

Point	Elevation head (he)	Pressure head (hp)	Total head (H)
A	L	$h_{pA}=H_1$	$L+H_1=h$
B	0.5 L	$0.5L+H_1-0.5h$ $=0.5h-0.5L$	$L+H_1-0.5h$ $=0.5h$
C	0	$h_{pC}=0$	0

(c)



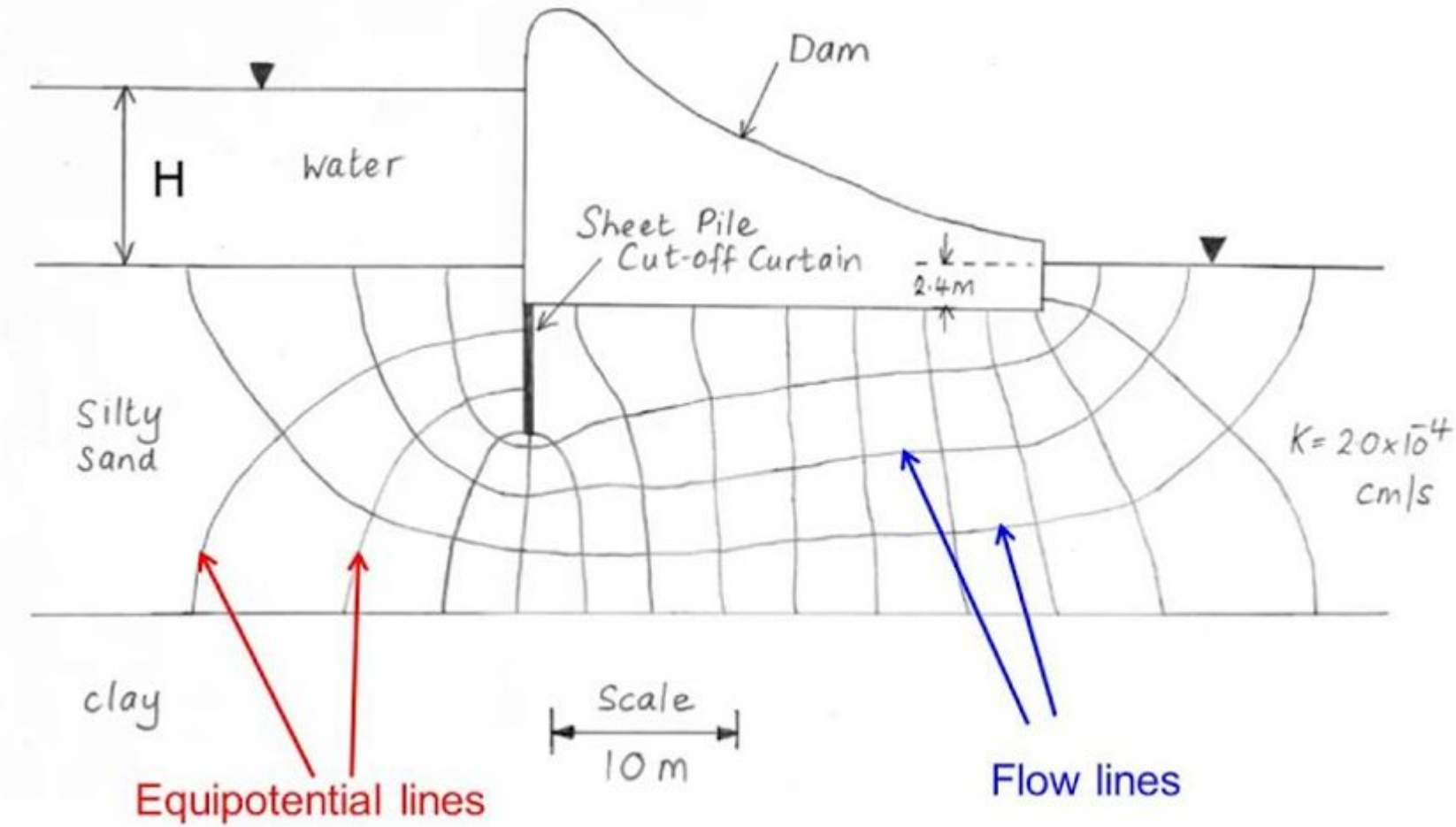
Flow net

(d)

0.5L + (h+L)-0.5h

- **Point B** is at a height of **0.5L above the datum**.
- As the rate of loss of head is linear, the loss of head up to point B is $\frac{h}{2}$ and **total head at point B is also $\frac{h}{2}$.**
- **Figure (d)** shows a simple flow net, in which **5 flow lines** and an **equal number of equipotential lines** are drawn.
- **Equipotential lines are horizontal** and **flow lines are vertical** in this case.
- If a **dye is inserted** at a few points on the top of the soil sample, **paths taken by the dye represent the flow lines.**
- But flow nets in actual soil engineering problems are not as simple as shown.

Flow Net Construction

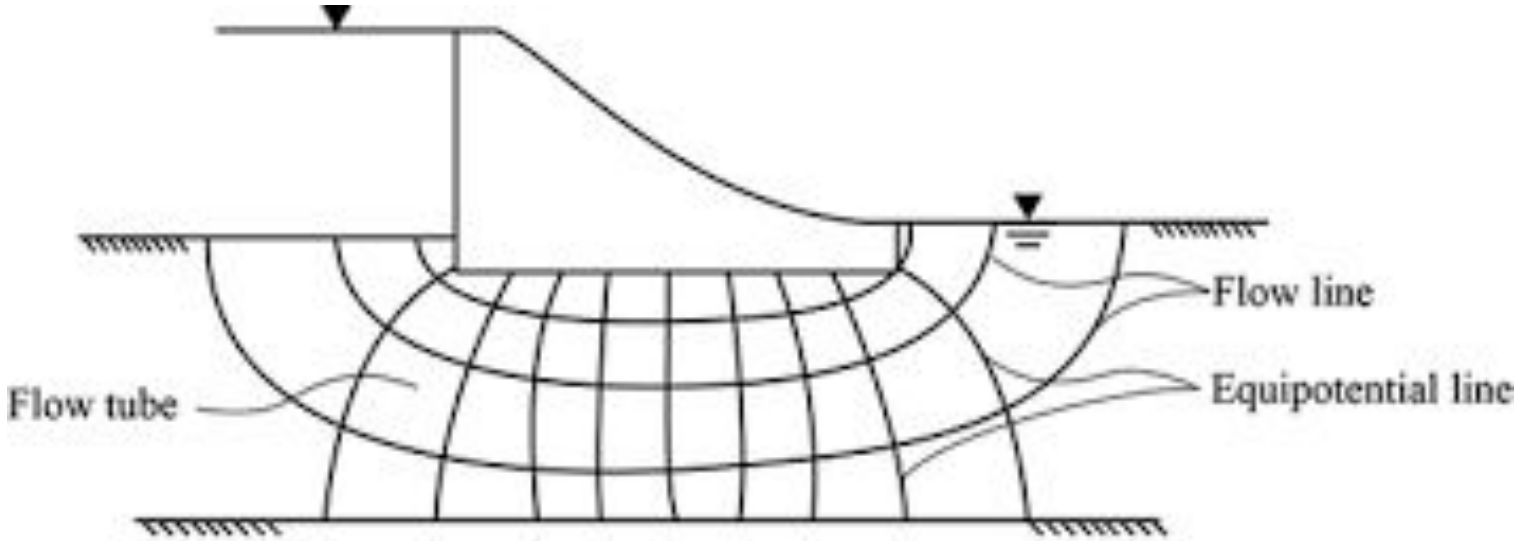


Properties of Flow Net

Flow Net Construction:

Properties of a flow net:

- Flow and equipotential lines are **smooth curves.**
- Flow lines and equipotential lines meet **at right angles** to each other.
- No two flow lines **cross** each other.
- No two flow or equipotential lines **start** from the same point.

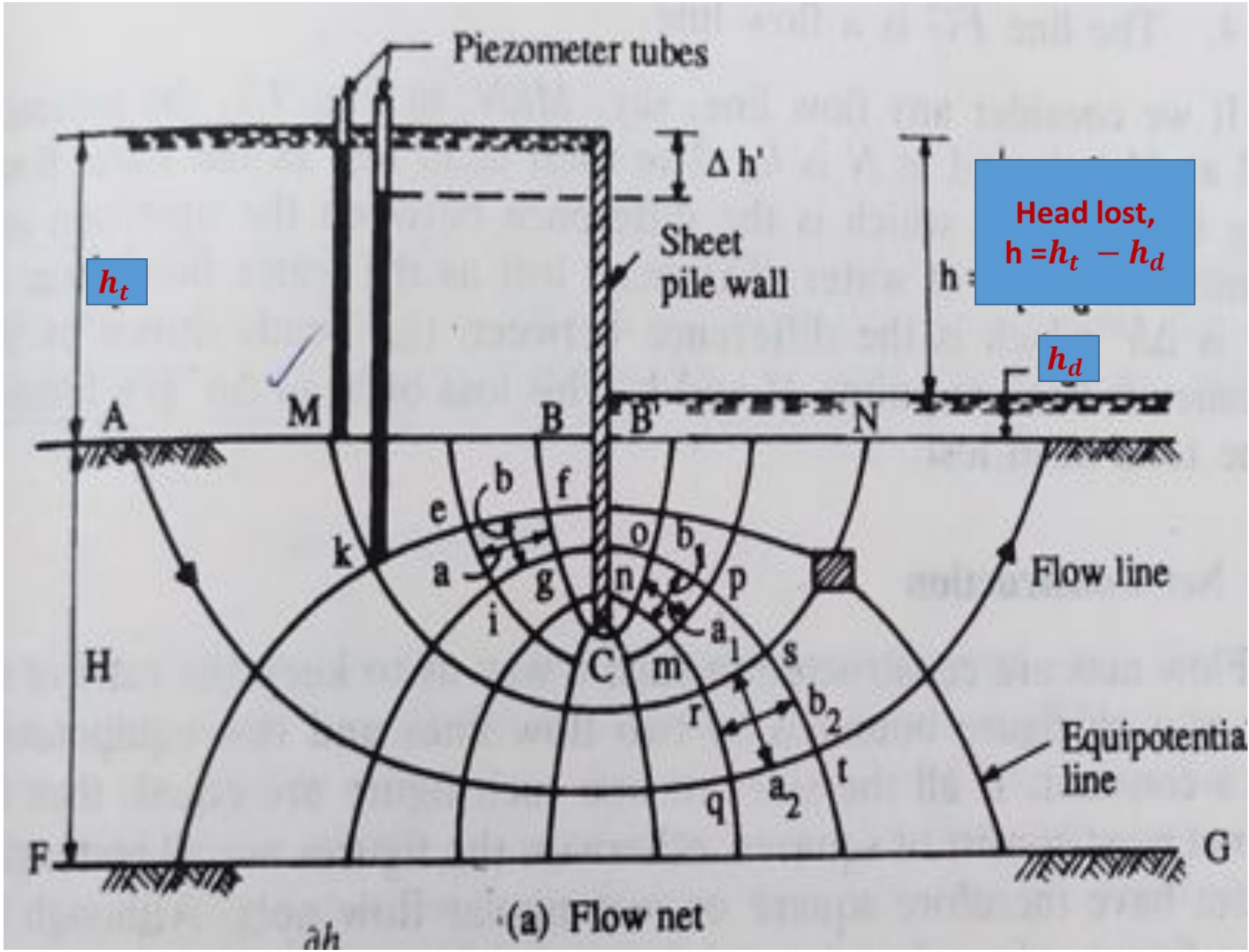


Flow net

Example of a Flow net for the flow below a sheet pile.

Figure: A typical example of a Flow net for the flow below a sheet pile.

- Head of water on the up-stream side of the sheet pile is h_t.
- Head on the downstream side is h_d.
- **Head lost** as water flows from up steam to down stream Side is h.



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Thank You