WATER IN SOIL - *Part 1*

By: Dr Hetty

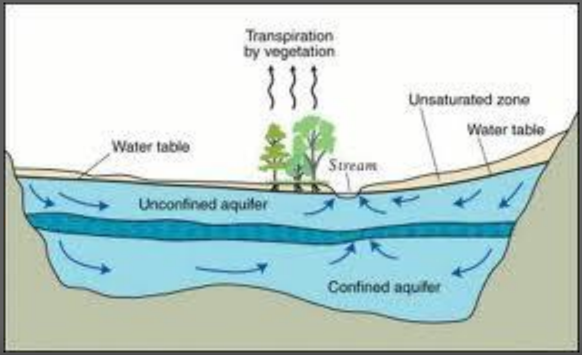
Important things

- How water flow in soil?
- How fast water flow in soil?
- Does water effect soil condition?
- Can water permit in geotechnical structures (Dam, Retaining Wall and etc.)?
- Why do we need to know water flow?

GroundWater

- Groundwater refers to all subsurface water
- Water beneath the surface of the earth which saturates the pores and fractures of sand, gravel, and rock formations.
- Water may occur close to the land surface, as in a wetland
- It may lie many hundreds of feet below the surface
- Groundwater is stored in, and moves slowly through, moderately to highly permeable rocks called *aquifer.*

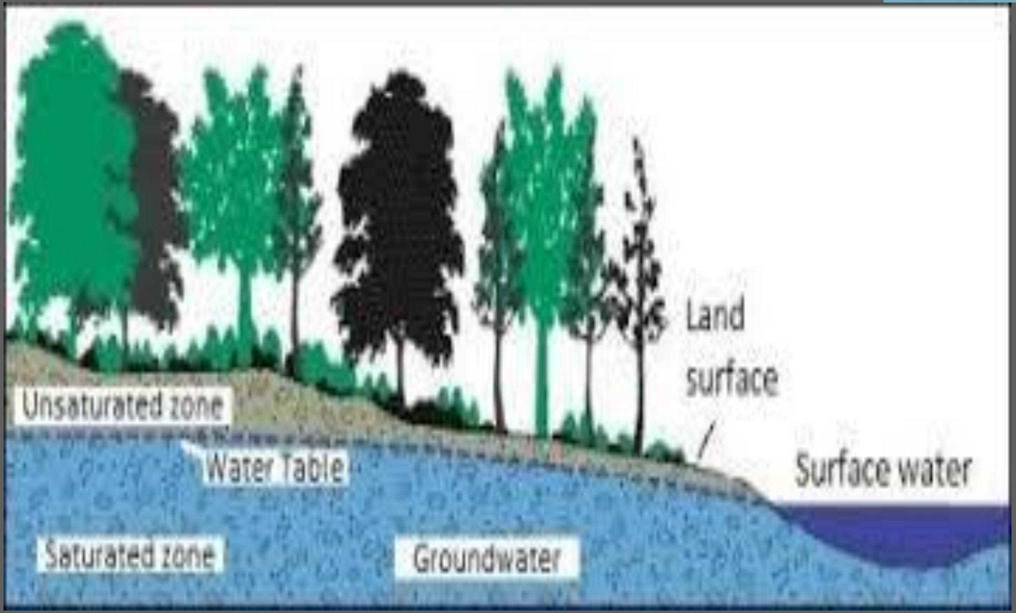
➲ An aquifer may be a layer of gravel or sand, a layer of sandstone or cavernous limestone, a rubbly top or base of lava flows, or even a large body of massive rock, such as fractured granite, that has sizable cracks and fissures.



Zone : GroundWater

(a) Vadose water

b) Phreatic water or gravitational



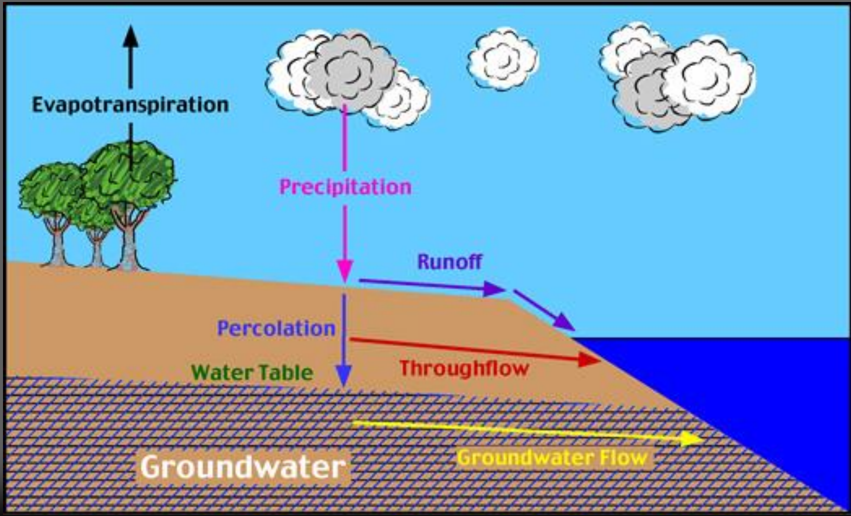
What is Vadose Water?

-Transient **percolating** water, moving downwards to join phreatic water below the water table.

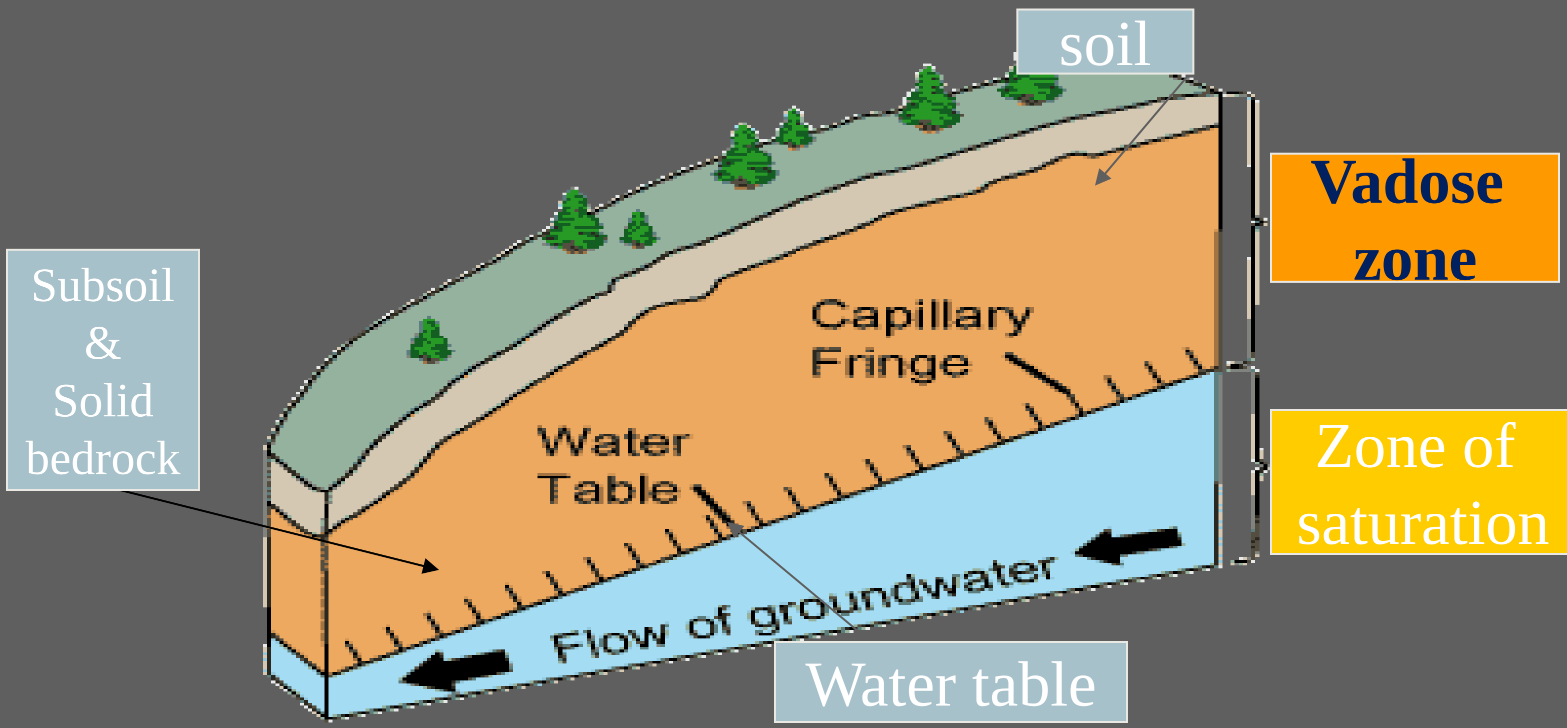
- *capillary water* held above the water table by surface tension forces (with internal pore pressure less than atmospheric).

- Vadose water is the water beneath the surface of the earth which is located above the level of the permanent groundwater.

- There are three distinct layers which is
  - soil (uppermost layer),
  - sub soil and solid bedrock (intermediate zone)
  - the water table (bottom layer).

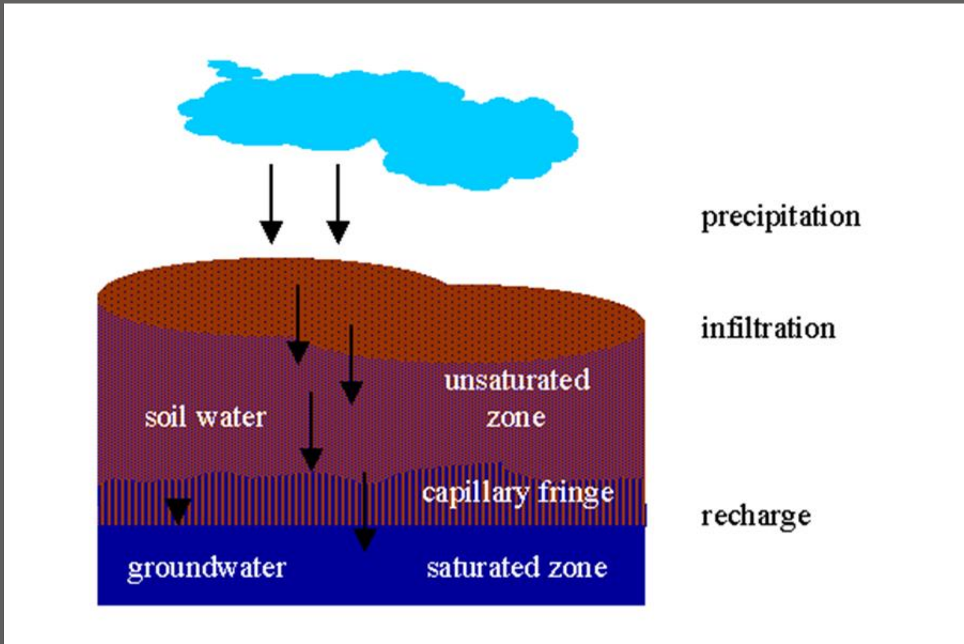


Position of Vadose Water



Capillary Fringe

- Capillary fringe is the lower layer.
- It is permanently wet and saturated with water sucked from the groundwater beneath.
- The height to which water will rise above the water table is because of this sponge like suction depends on the texture of the material holding the water.
- The water move much higher in the fine-grained material due to the capillarity force.



How water can enter the ground and become vadose water?

The major sources of natural recharge are: -

- Precipitation (rain and snow)
- Stream flow
- Reservoirs

The artificial recharge are due to: -

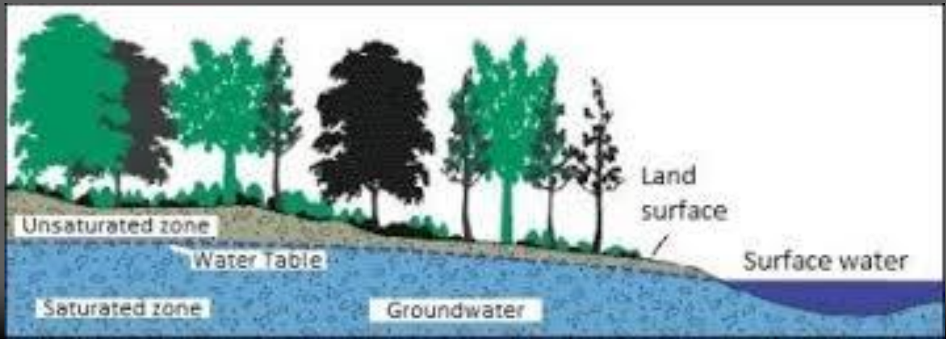
- Excessive irrigation
- Seepage from canal

WATER TABLE

- It is phreatic surface
- Above the water table is vadose wter and below the water table is phreatic water

PHREATIC WATER??

- Is forms cave passages by dissolving the limestone in all directions as opposed to vadose action whereby a stream running in a cave passage erodes a trench in the floor.
- Usually take place below water table.
- It is saturated (consists water and soil)
- Phreatic/gravitational water which:
  - Subject to gravitational forces
  - Saturated the pore space in the soil below the water table
  - Has n internal pore pressure



Forces on Soil Water

Gravitational - pull of gravity downward

Adhesion - attraction of water to soil

Cohesion - attraction of water to water

Capillary - taken up by plants

WATER RETENTION

Medium-textured soils have the highest available water-holding capacity e.g. Silt Loam

Organic matter influences water-holding capacity

Increases amount of available water

TYPICAL VALUES :WATER RETENTION

Texture	Field Capacity (in./ft)	Permanent Wilting Point (in./ft)	Available Water (in./ft)
Fine sand	1.4	0.4	1.1
Sandy loam	1.9	0.6	1.4
Fine sandy loam	2.5	0.8	1.8
Loam	3.1	1.2	1.95
Silt loam	3.4	1.4	2.03
Clay loam	3.7	1.8	1.95
Clay	3.9	2.5	1.4

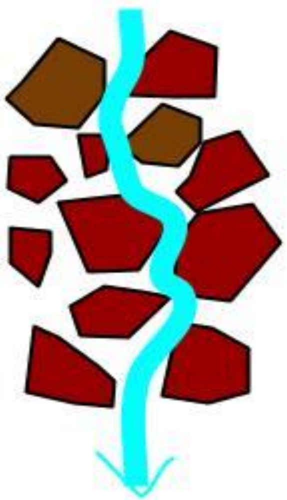
FIGURE 7-7 Water retention of several soil textures. *(Adapted from Water: The Yearbook of Agriculture, USDA, 1955)*

Water Flows through Soil (1 D)

- As water flows through pipes it will also flow to any mediums that permit
- Water could flow through soil medium that can be explained by the Bernoulli's equations

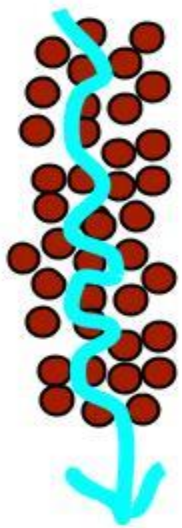
Water Movement through Soil Particles

Gravel



Big particles with lots of space between means the water can move quickly through

Sand

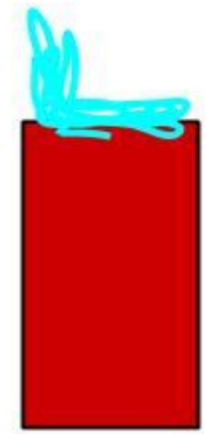


Space between particles is smaller, water moves slower through it

Silt

spaces between particles is even smaller and water moves slowly through

Clay



Barely any space between particles for water to move through, water can take 100's of years to move through

Bernoulli Equation

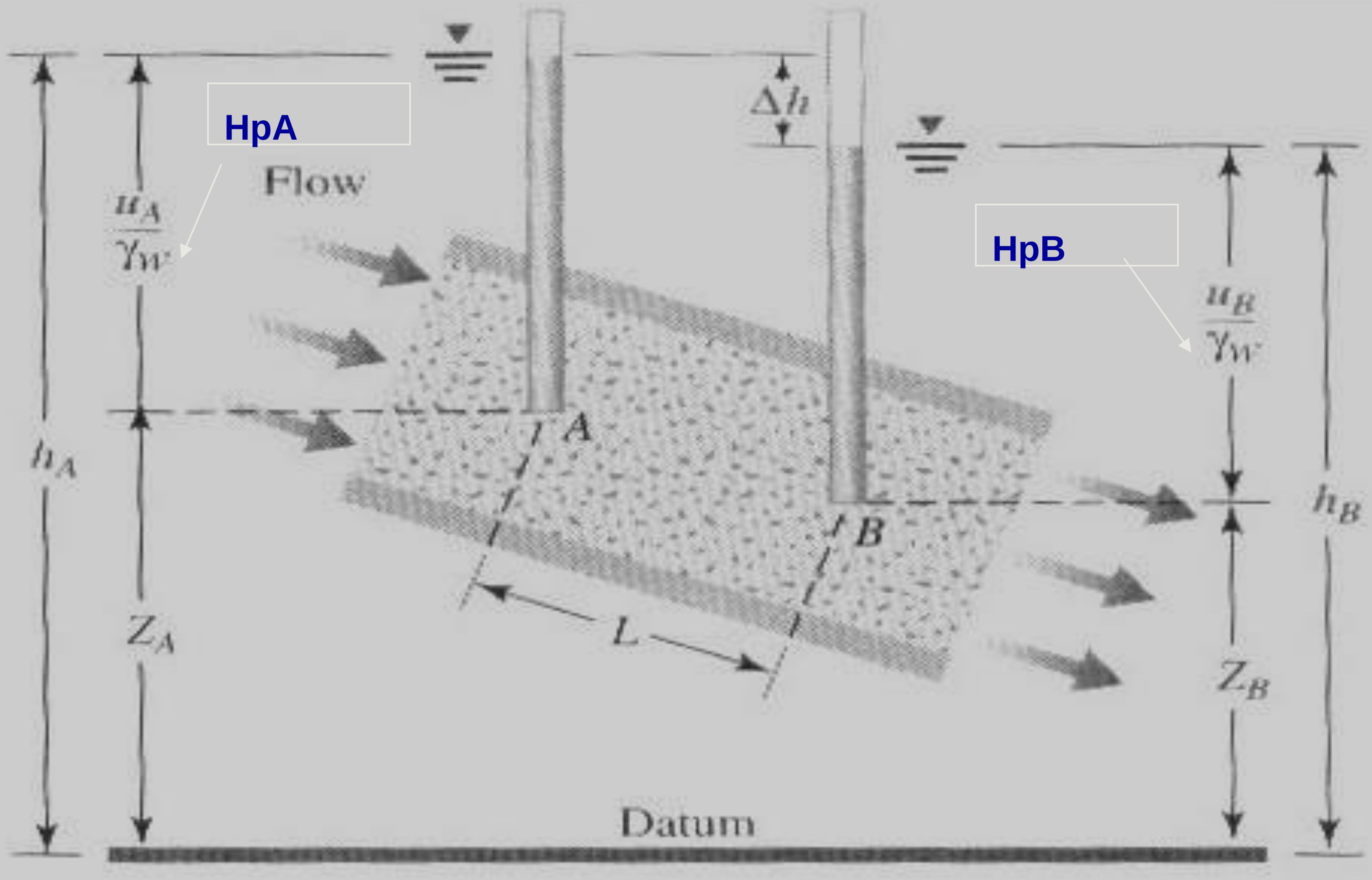
- $h_t = h_z + \frac{u}{\gamma_w} + \frac{v^2}{2g} = h_z + h_p$

- where h_z = position or elevation head

  $\frac{u}{\gamma_w}$ = pressure head to pore pressure

  $\frac{v^2}{2g}$ = velocity head

- *Water will flow through soil if there exists a difference of head within 2 points*



$$\blacktriangle Ht_{A\text{-}B} = h_{TA} - h_{TB}$$

$$= (Z_A + h_{pA}) - (Z_B + h_{pB})$$

Darcy Law For Saturated Flow

- In saturated conditions, one-dimensional flow is governed by Darcy's Law, which states that the *flow velocity is proportional to the hydraulic gradient*:

$$v \propto i \quad \text{or} \quad v = ki$$

where

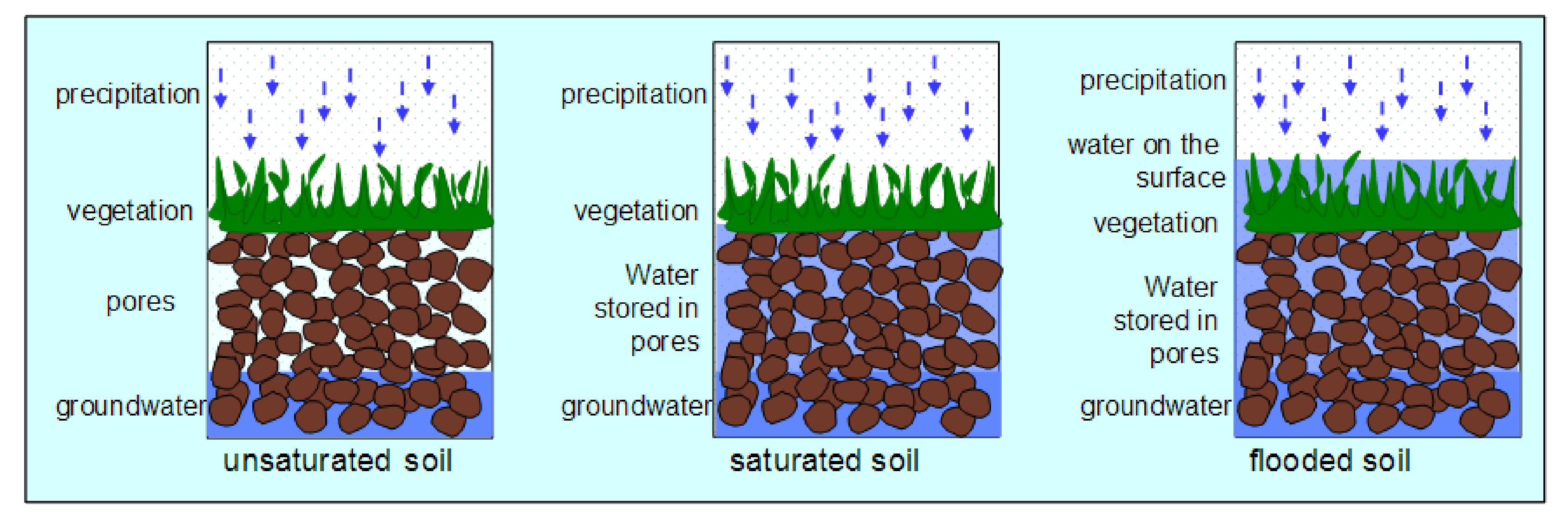
v = flow velocity

k = the flow constant or coefficient of permeabilitY

i = the hydraulic gradient = $\frac{\Delta h}{\Delta L}$

Δh = difference in total head over a flow

ΔL = path length



Permeability

- The permeability of a soil is a measure of its capacity to allow the flow of water through the pore spaces between solid particles.
- The degree of permeability is determined by applying a hydraulic pressure gradient, *i* in a sample and measuring the consequent rate of flow of water.
- The coefficient of permeability is expressed as velocity, (mm/s^2)
- “the larger a soil’s void space, the greater will be its permeability. Conversely, the smaller the void space, the lesser will be it’s permeability”
- Therefore, coarse soil > fine soil on permeability value.

Factors : Permeability

The value of k is used as a measure of the resistance to flow by the soil, and it is affected by several factors:

a) The *porosity of the soil*

b) The *particle size distribution*

c) The *shape and the orientation of soil particles*

d) The *degree of saturation/presence of air*

e) The *type of cation and thickness of adsorbed layers associated with clay minerals (if present)*

f) The *viscosity of the soil water, which varies with temperature*

Typical Values: Permeability

k value (m/s)	Type of soil	Note
10^{2}	Clean gravels	Very good drainage
10^{1}		
1		
10^{-1}		
10^{-2}	Clean sands Gravel-sand mixtures	
10^{-3}		Good drainage
10^{-4}		
10^{-5}	Very fine sands Silts and silty sands	Poor Drainage
10^{-6}		
10^{-7}	Clay silts (>20% clay)	
10^{-8}		Practically impervious
10^{-9}		

Testing: Permeability

- **Laboratory**
  - Falling Head Test
  - Constant Head Test

- **Field (In Situ)**
  - Pumping
  - Borehole
  - Tracer tests

See you later……………