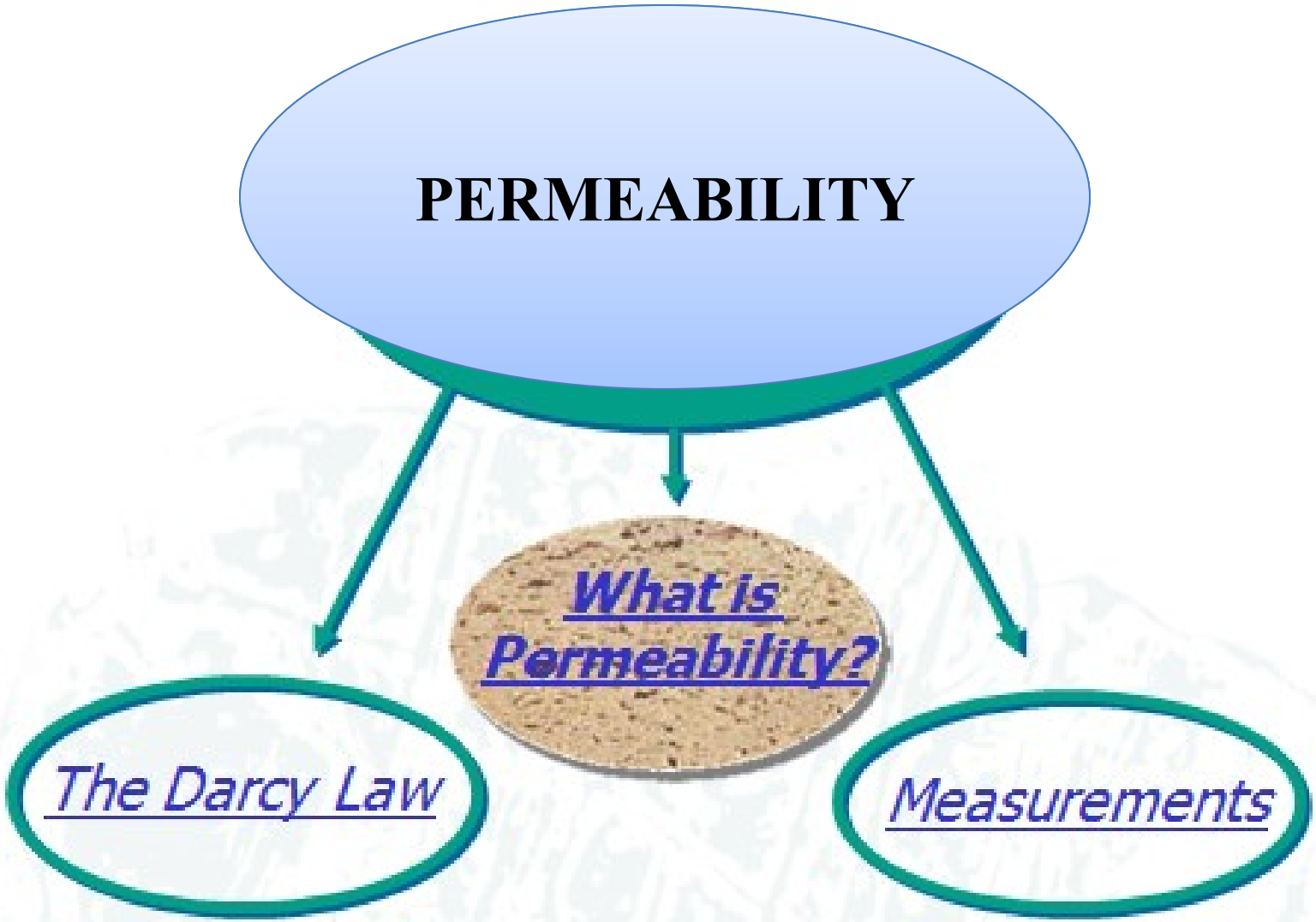
Permeability

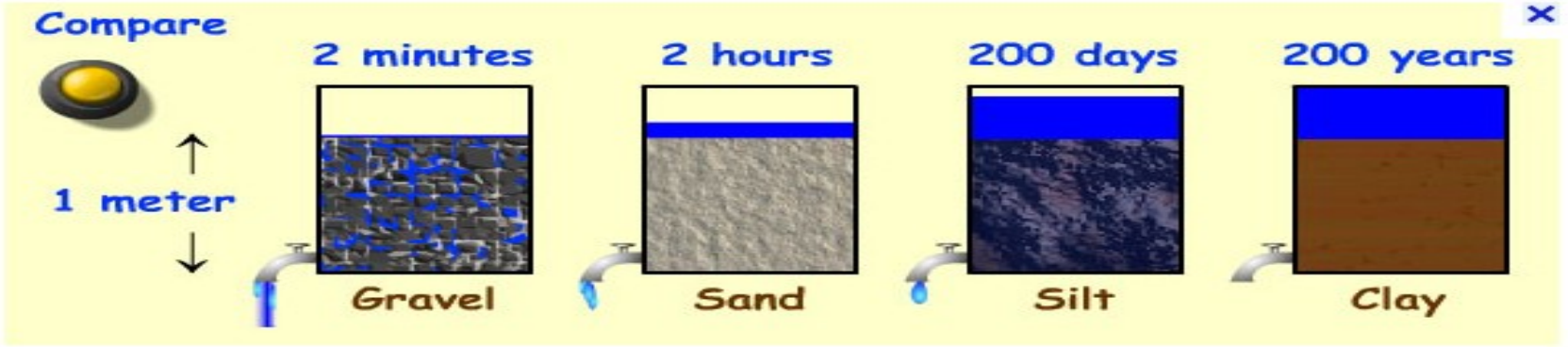

PERMEABILITY
What is Permeability?
The Darcy Law
Measurements

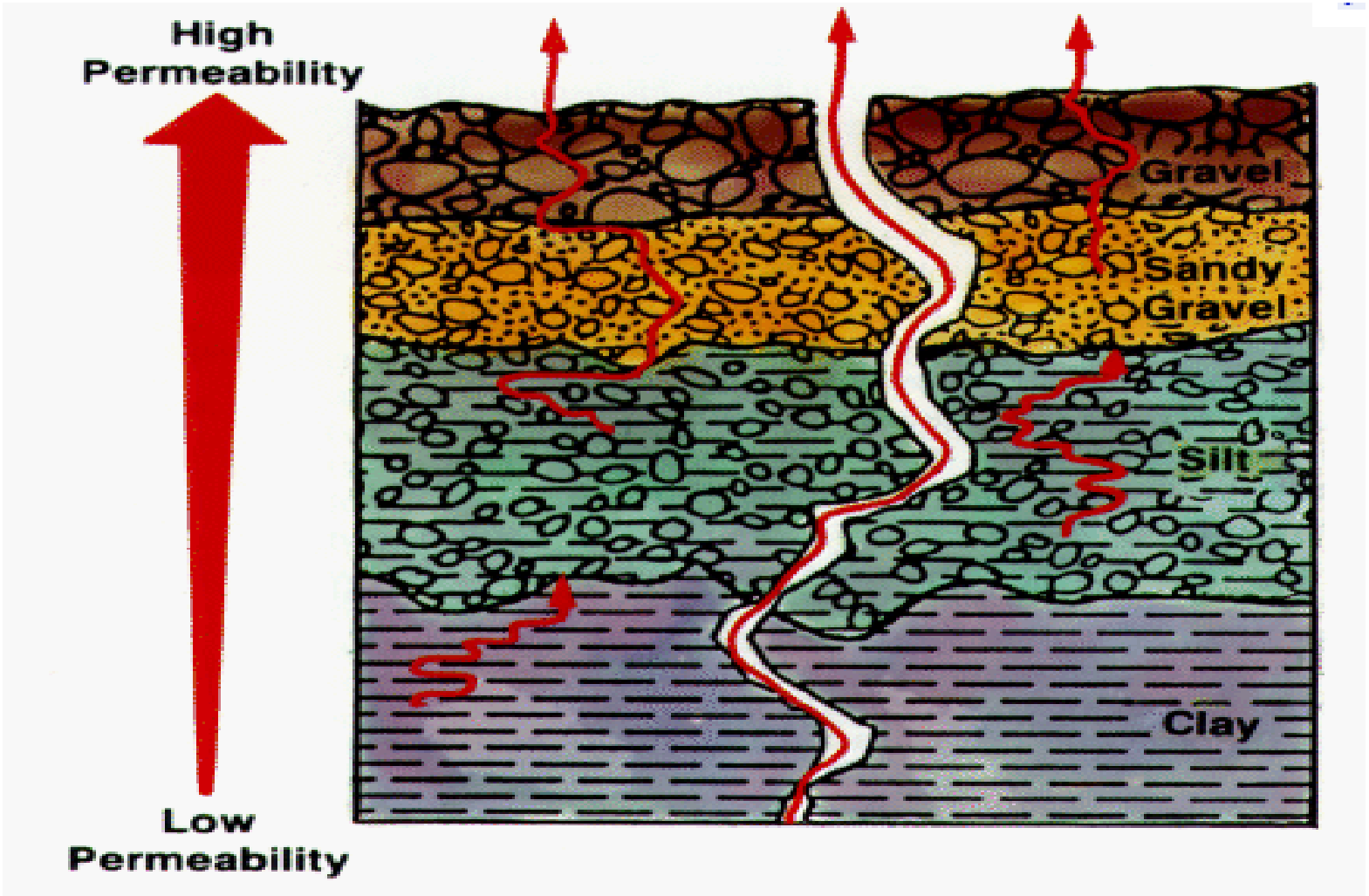
What is **permeability**?

- Property of a soil which permits the flow of water
- Permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids.
- It is a very important Engineering property

gravels ⟹ highly permeable

stiff clay ⟹ least permeable


Compare
2 minutes
2 hours
200 days
200 years
1 meter
Gravel
Sand
Silt
Clay

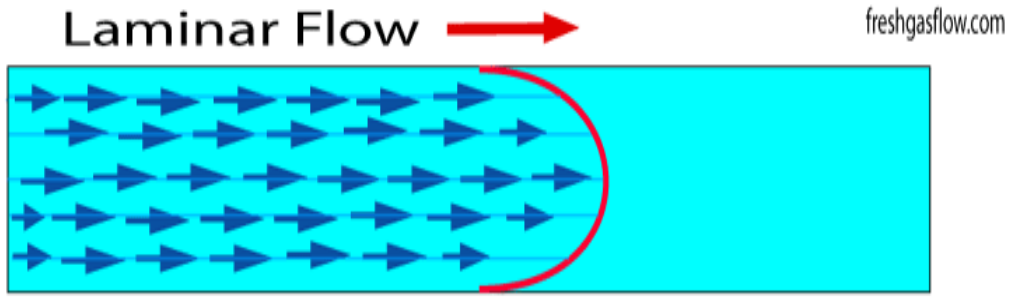

High Permeability
Low Permeability
Gravel
Sandy Gravel
Silt
Clay

Permeability through soil is important for the following engineering problems:

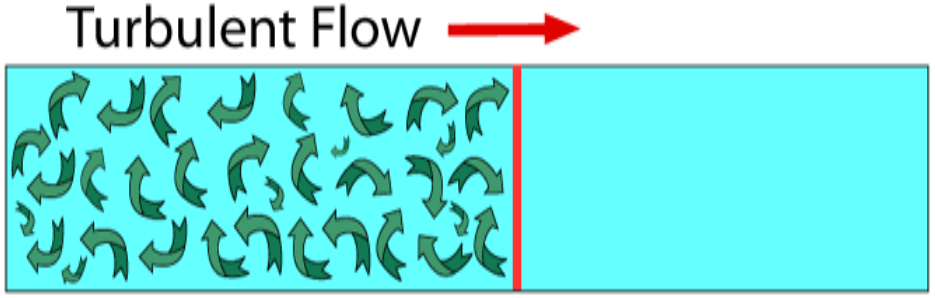
- **Calculation** of uplift pressure under hydraulic structure and their safety against **piping**
- Ground water flow towards wells and drainage of soil
- Calculation of seepage through the body of earth dams and **stability** of slopes
- Determination of rate of **settlement** of a saturated compressible soil layer

Flow of water through soils may either be a **laminar flow** or a **turbulent flow**

Each fluid particle travel along a definite path which never crosses the path of any other particle



Paths are irregular and twisting, crossing at random



Coefficient Of Permeability

Depends not only on the properties of soil but also on the properties of water

Absolute permeability

- Independent of the properties of water
- It depends only on the characteristics of soil
- The absolute permeability only depends on the geometry of the pore-channel system.

Relative permeability is the ratio of effective permeability of a particular fluid to its absolute permeability.

Henry Darcy (1803-1858), Hydraulic Engineer. His law is a foundation stone for several fields of study

Darcy's Law who demonstrated experimentally that for laminar flow conditions in a saturated soil, the rate of flow or the discharge per unit time is proportional to the hydraulic gradient

$$q = vA$$

$$v = ki$$

$$q = kiA$$

Validity of darcy's law - When flow is laminar

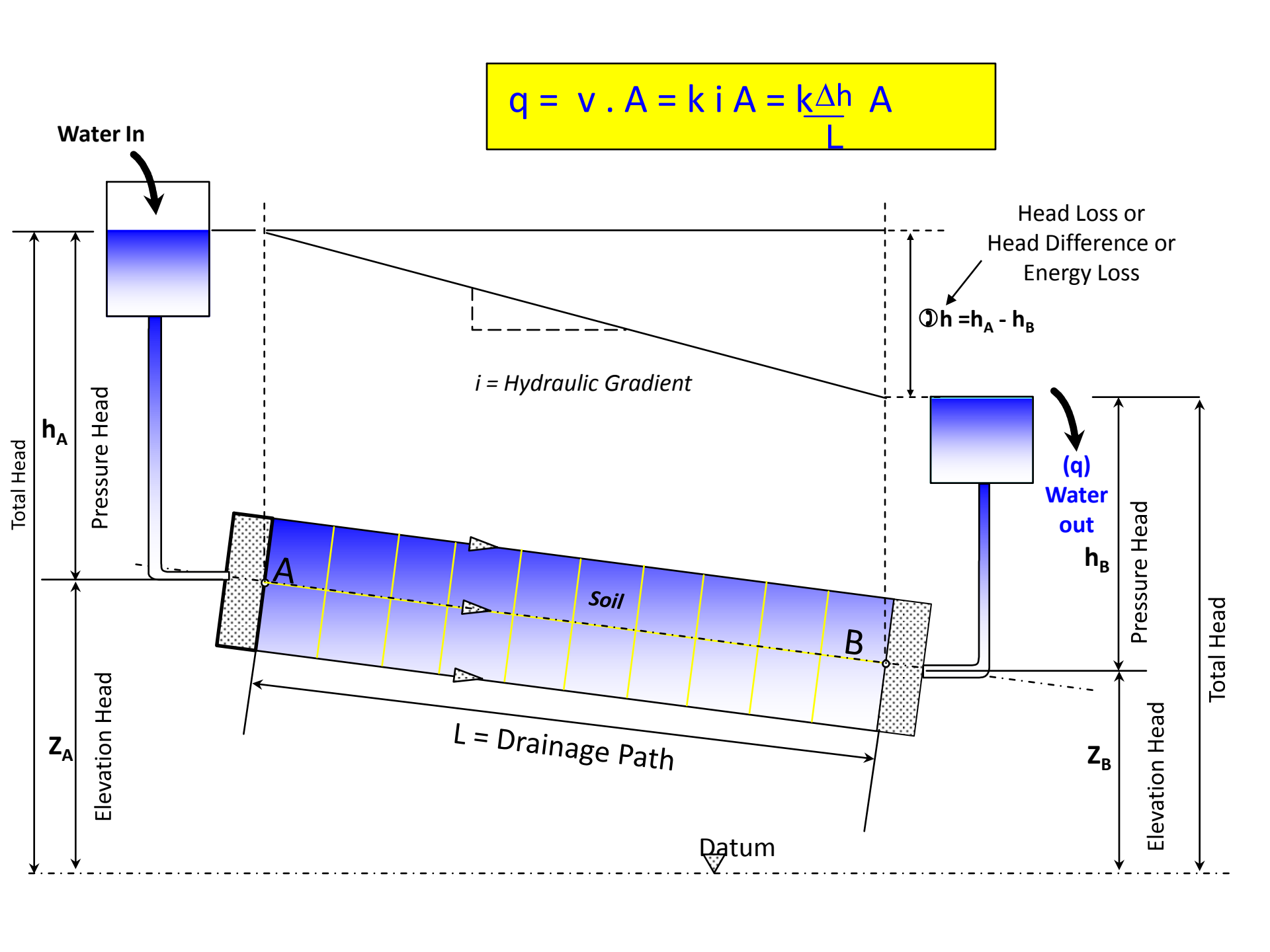
Bernouli's Equation:

- Total Energy = Elevation Energy + Pressure Energy + Velocity Energy

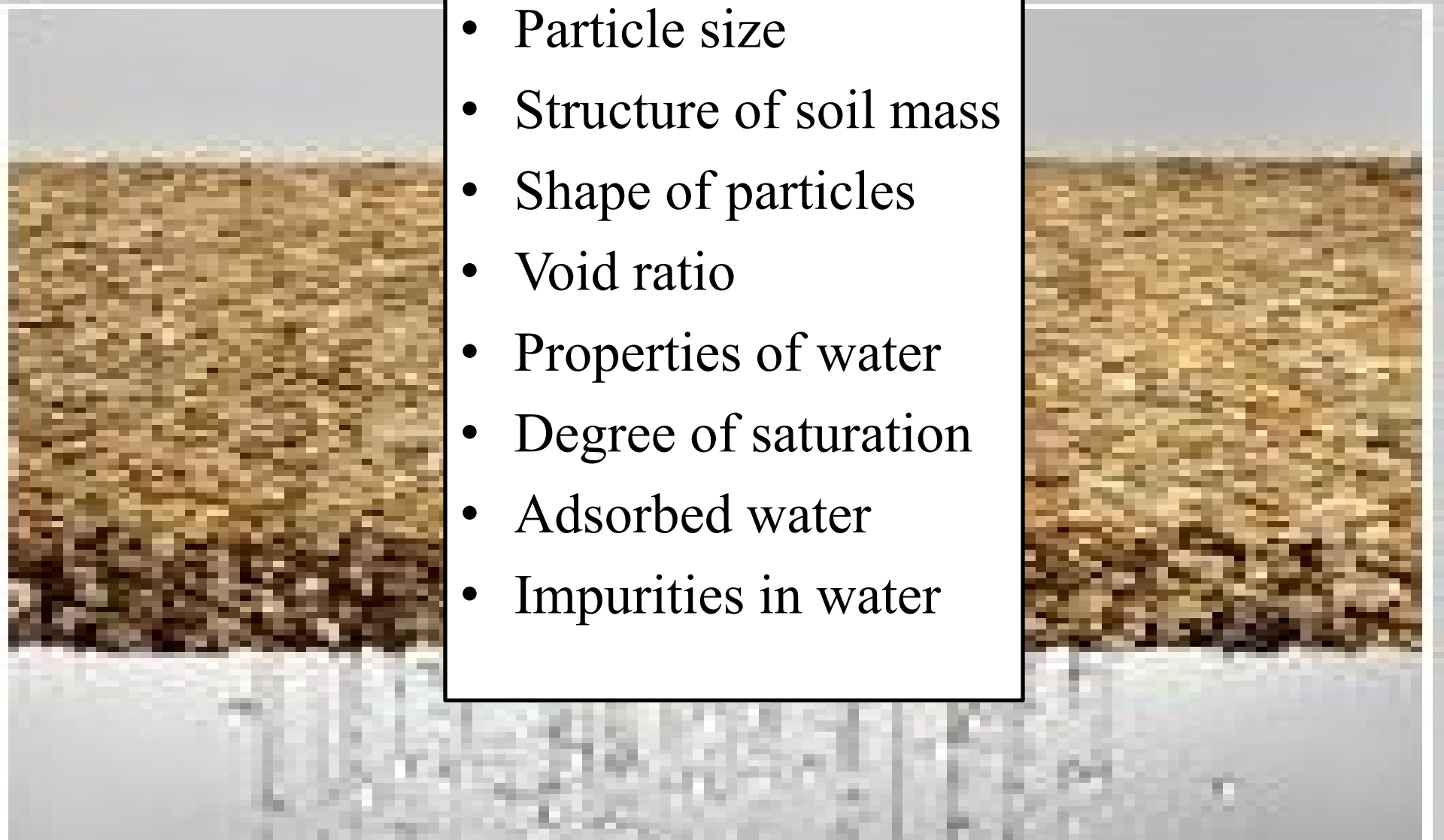
- Total Head = Elevation Head + Pressure Head + Velocity Head

$$H = z + \frac{v^2}{2g} + \frac{p}{\rho g}$$

- Total head of water in soil engineering problems is equal to the sum of the elevation head and the pressure head

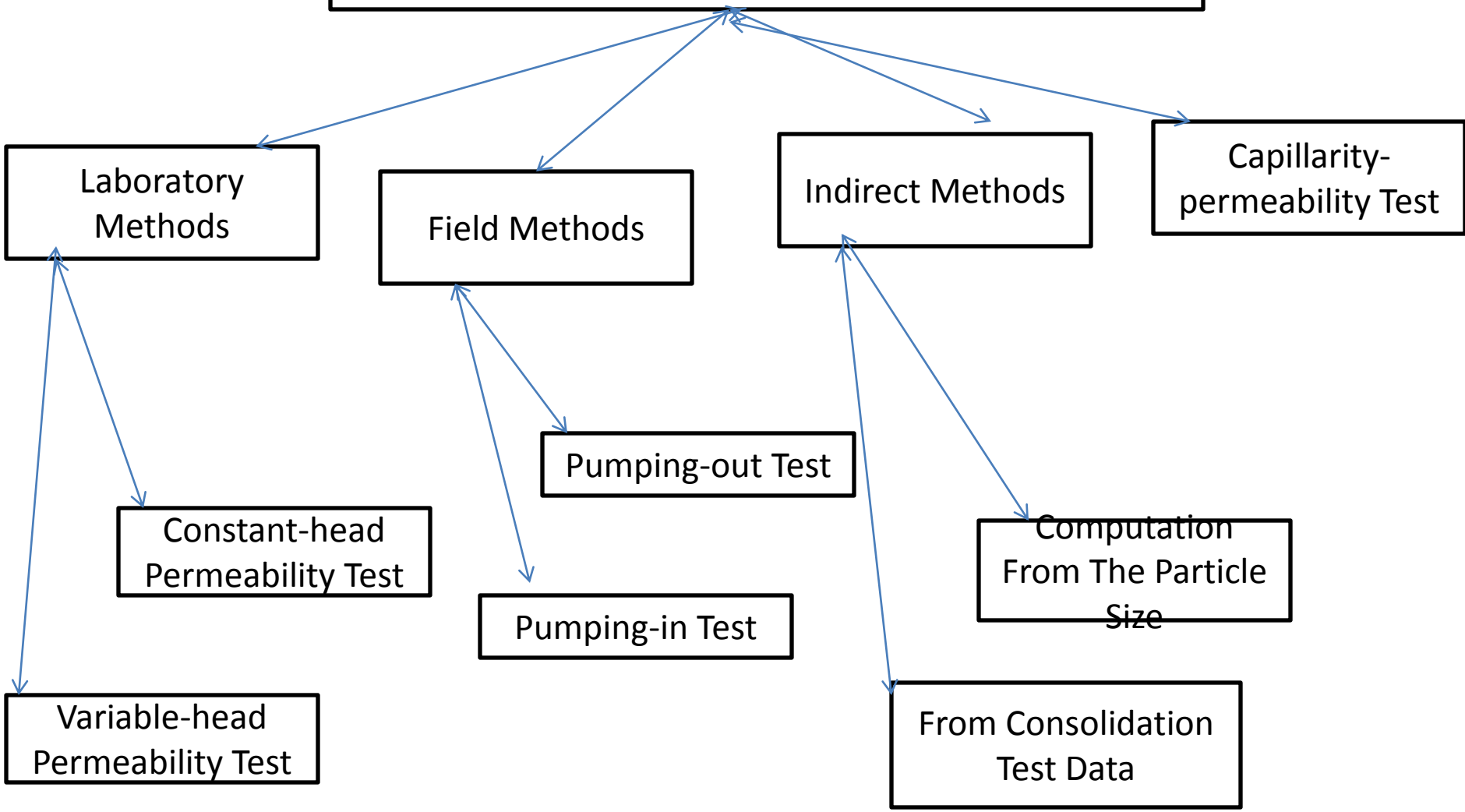

$q = v \cdot A = k\,i\,A = k\frac{\Delta h}{L} A$
Water In
Head Loss or
Head Difference or
Energy Loss
$\Delta h = h_A - h_B$
i = Hydraulic Gradient
Total Head
h_A
Pressure Head
A
Soil
B
(q)
Water
out
h_B
Pressure Head
Total Head
Z_A
Elevation Head
L = Drainage Path
Z_B
Elevation Head
Datum

Factors Affecting Permeability



- Particle size
- Structure of soil mass
- Shape of particles
- Void ratio
- Properties of water
- Degree of saturation
- Adsorbed water
- Impurities in water

Determination Of **Coefficient Of Permeability**



Constant Head Permeability Test

- Quantity of water that flows under a given hydraulic gradient through a soil sample of known length & cross sectional area in a given time
- Water is allowed to flow through the cylindrical sample of soil under a constant head
- For testing of pervious, coarse grained soils

$$k = \frac{QL}{Aht}$$

K = Coefficient of permeability

Q = total quantity of water

t = time

L = Length of the coarse soil

Variable head permeability test

- Relatively for less permeable soils
- Water flows through the sample from a standpipe attached to the top of the cylinder.
- The head of water (h) changes with time as flow occurs through the soil. At different times the head of water is recorded.

$$k = \frac{2.30aL}{At} \log_{10} \frac{h_1}{h_2}$$

t = time

L = Length of the fine soil

A = cross section area of soil

a= cross section area of tube

K = Coefficient of permeability

By Indirect Method

Allen hazen's formula

$$k = cD_{10}^{\ 2}$$

Kozeny carman equation

$$k = \frac{g\rho_w}{(C_s \mu S^2)T^2} \frac{e^3}{1+e}$$

Loudon's formula

$$\log_{10}(kS^2) = a + bn$$

Consolidation test data

$$k = C_v \gamma_w m_v$$

constants.,a= 1.365
b=5.15
c=value b/w 100 & 150
T= Tortuosity
S = surface area

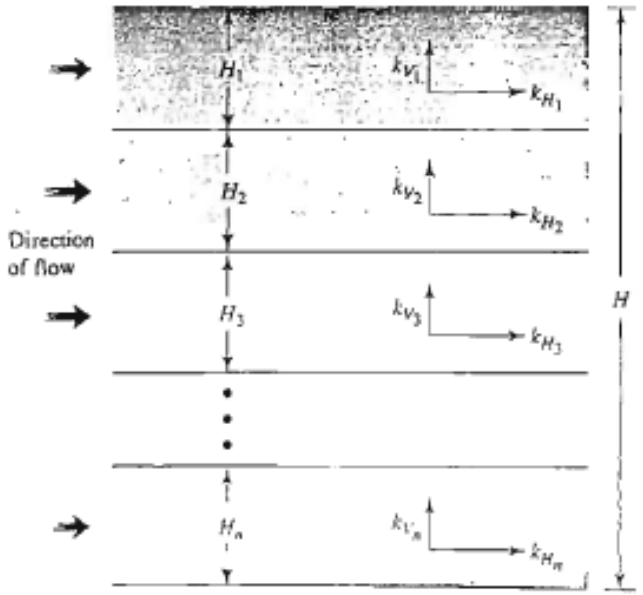
Permeability in Stratified Soils

Flow parallel to the plans of stratification

$$q = kiA$$

$$q = k_x iH = (k_1 H_1 + k_2 H_2 + \cdots k_n H_n)i$$

$$k_x = \frac{k_1 H_1 + k_2 H_2 + \cdots k_n H_n}{H}$$



Flow normal to the plans of stratification

$$k_y = \frac{H}{\frac{H_1}{k_1} + \frac{H_2}{k_2} + \cdots + \frac{H_n}{k_n}}$$