GEO TECHNICAL ENGINEERING

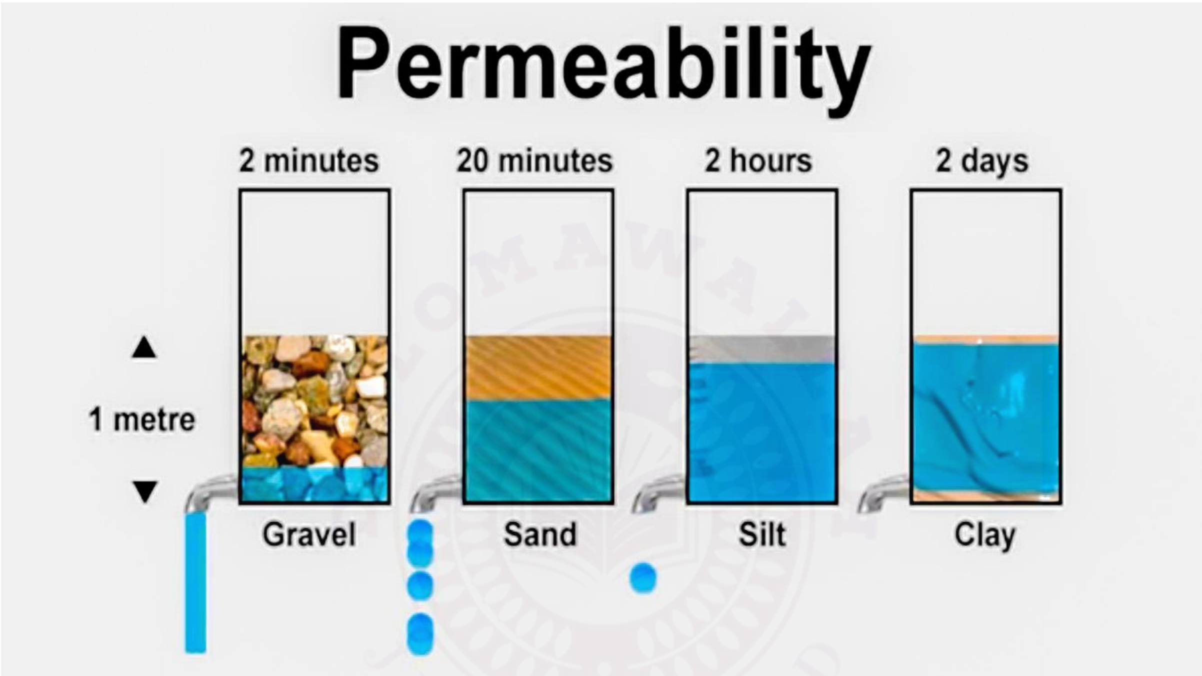
DIPLOMA WALLAH

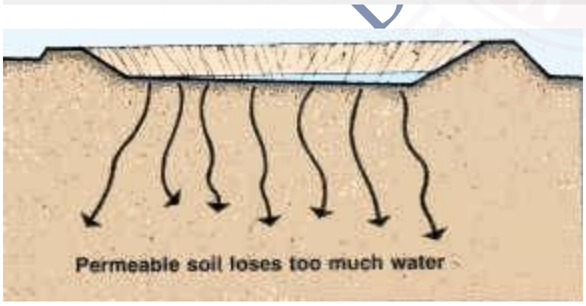
CIVIL

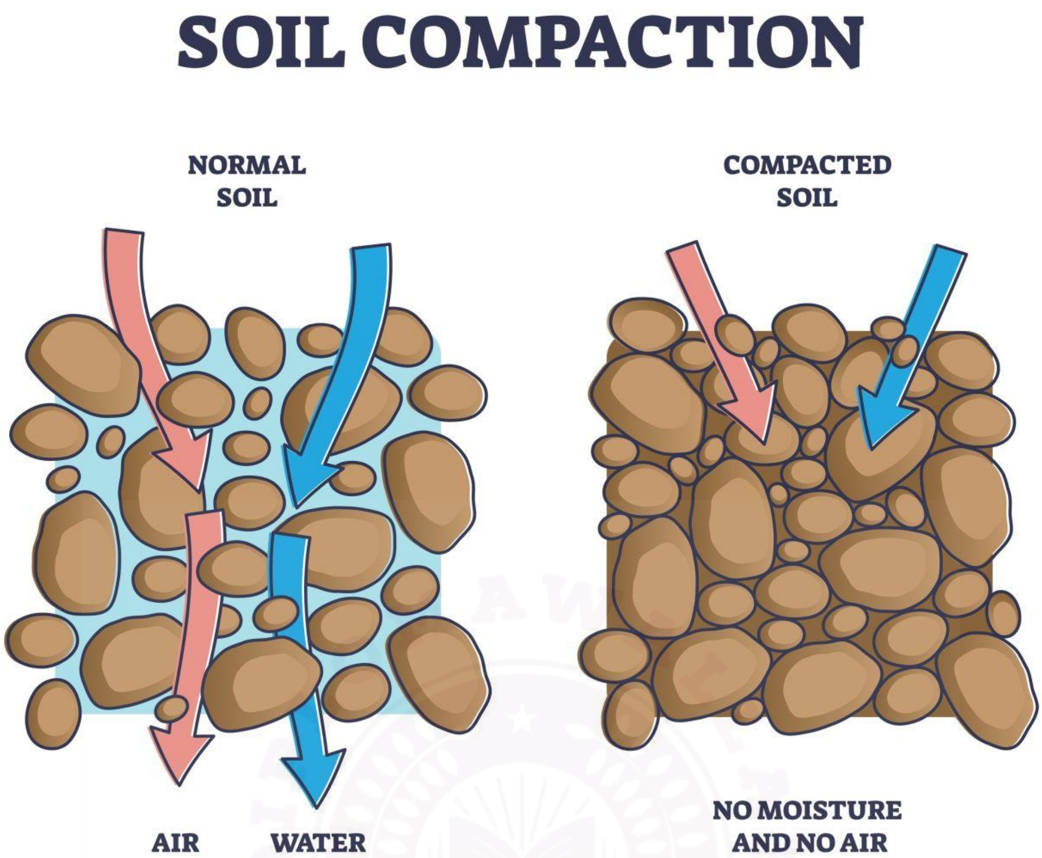
Jharkhand University Of Technology (JUT)

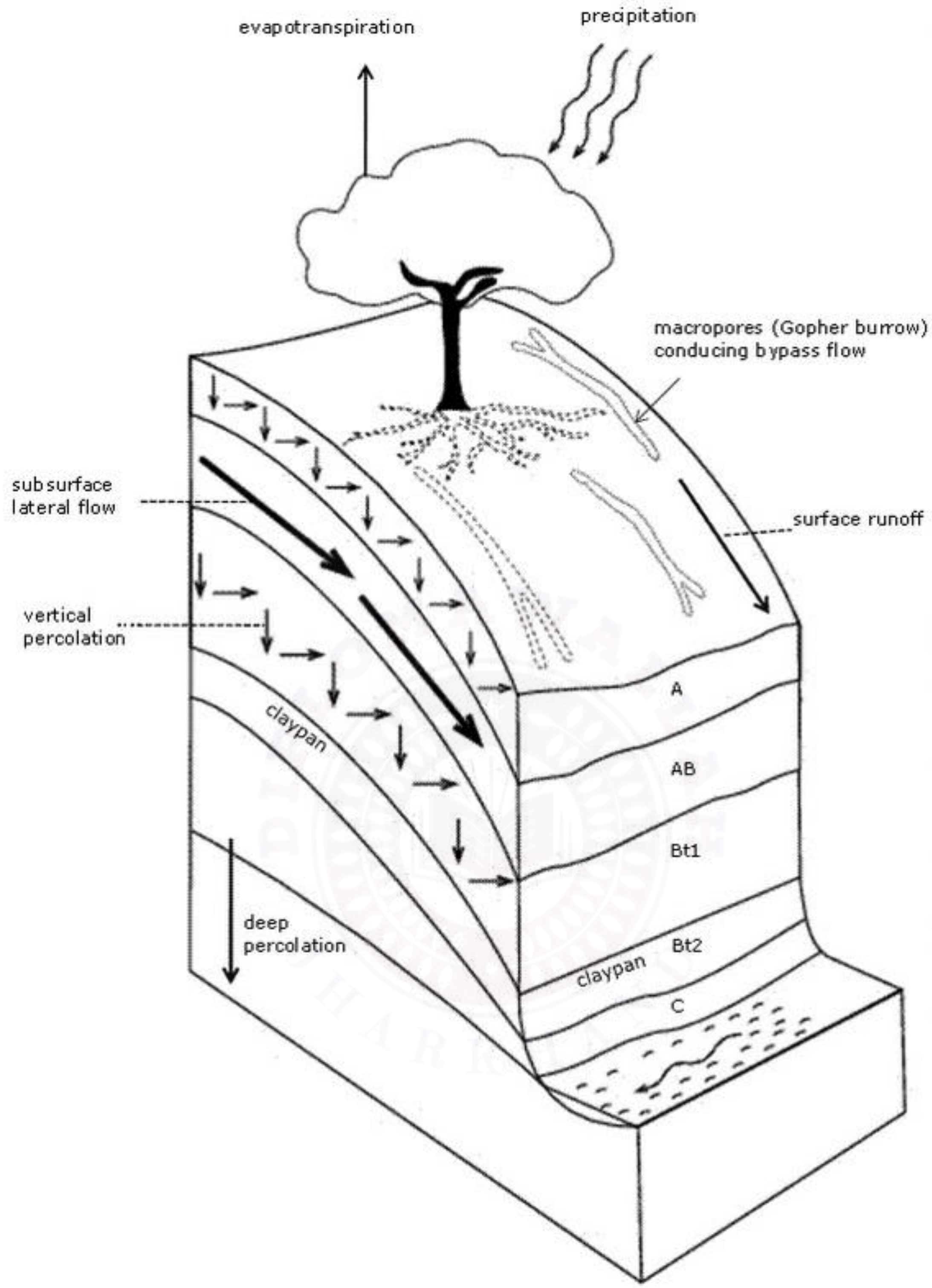
Unit – III :- Permeability and Shear Strength of Soil

1. Definition of permeability






SOIL COMPACTION
NORMAL SOIL
COMPACTED SOIL
AIR
WATER
NO MOISTURE AND NO AIR


evapotranspiration
precipitation
macropores (Gopher burrow)
conducing bypass flow
subsurface
lateral flow
surface runoff
vertical
percolation
claypan
A
AB
Bt1
deep
percolation
Bt2
claypan
C

Learning Outcomes:

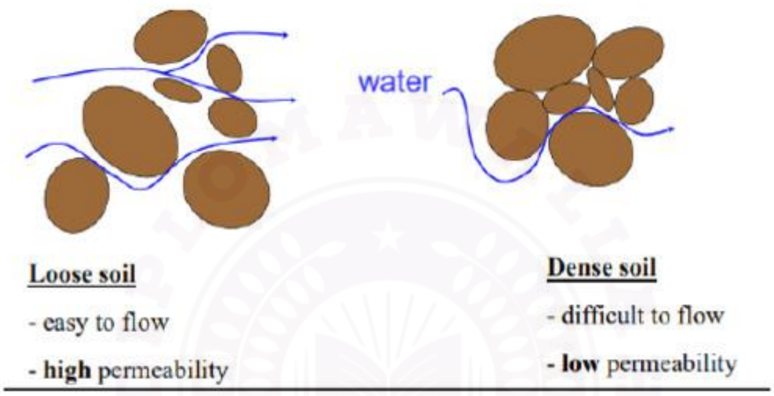
- Understand basic principles of flow and soil permeability through porous media including Bernoulli's equation, Darcy's law, and hydraulic conductivity
- Understand seepage in soil

Permeability

Soils are permeable due to the existence of interconnected voids through which water can flow from points of high energy to points of low energy. The study of the flow of water through permeable soil media is important in soil mechanics. It is necessary for estimating the quantity of underground seepage under various hydraulic conditions, for investigating problems involving the pumping of water for underground construction, and for making stability analyses of earth dams and earth-retaining structures that are subject to seepage forces.

What is permeability?

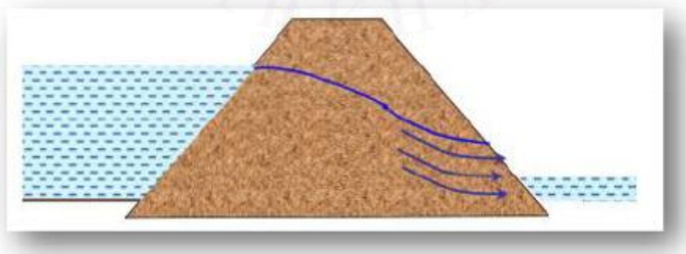
– Permeability is the measure of the soil's ability to permit water to flow through its pores or voids



Importance of Permeability

The following applications illustrate the importance of permeability in geotechnical design:

- The design of earth dam is very much based upon the permeability of the soils used.
- The stability of sopes and retaining structures can be greatly affected by the permeability of the soils involved.



Soil type	Permeability k (m/sec)	Reducing permeability
Gravel	>0.1	↓
Sand	$0.1 – 10^{-4}$	
Silt	$10^{-4} – 10^{-8}$	
Clay	$<10^{-8}$	

Definition:
In soil mechanics, permeability (also called *hydraulic conductivity*) is the measure of the ability of a soil to allow water (or other fluids) to flow through its void spaces under a hydraulic gradient. It reflects how easily fluid can pass through the soil medium. (theconstructor.org)

Expanded Explanation:

- The soil must have interconnected voids for flow to happen; the void size, void ratio, particle size, shape and connectivity of the voids all influence permeability. (theconstructor.org)
- Even if there are large voids, if they are not connected (blocked by fines or clay membranes) the permeability may be low.
- The fluid properties (viscosity, density) also affect the rate of flow through the soil—while the term "permeability" is sometimes used loosely, strictly speaking, the soil property is independent of the fluid (but in practice fluid properties matter). (perminc.com)
- In design contexts: soils with high permeability (e.g., gravels, coarse sands) allow rapid drainage, less water accumulation; soils with very low permeability (clays) retain water, may build up pore pressures, influence foundation performance, seepage, embankments.

Key Points to write in exam:

- Give the definition clearly.
- Mention the term hydraulic conductivity, symbol (often (k) or (K)).
- Explain factors affecting permeability (particle size, void ratio, saturation, fluid properties).
- Mention typical relative orders of magnitude (coarse soils high, fine soils low) if needed.

- Highlight engineering significance—why permeability matters (drainage, seepage control, foundation stability, earthworks, liners).

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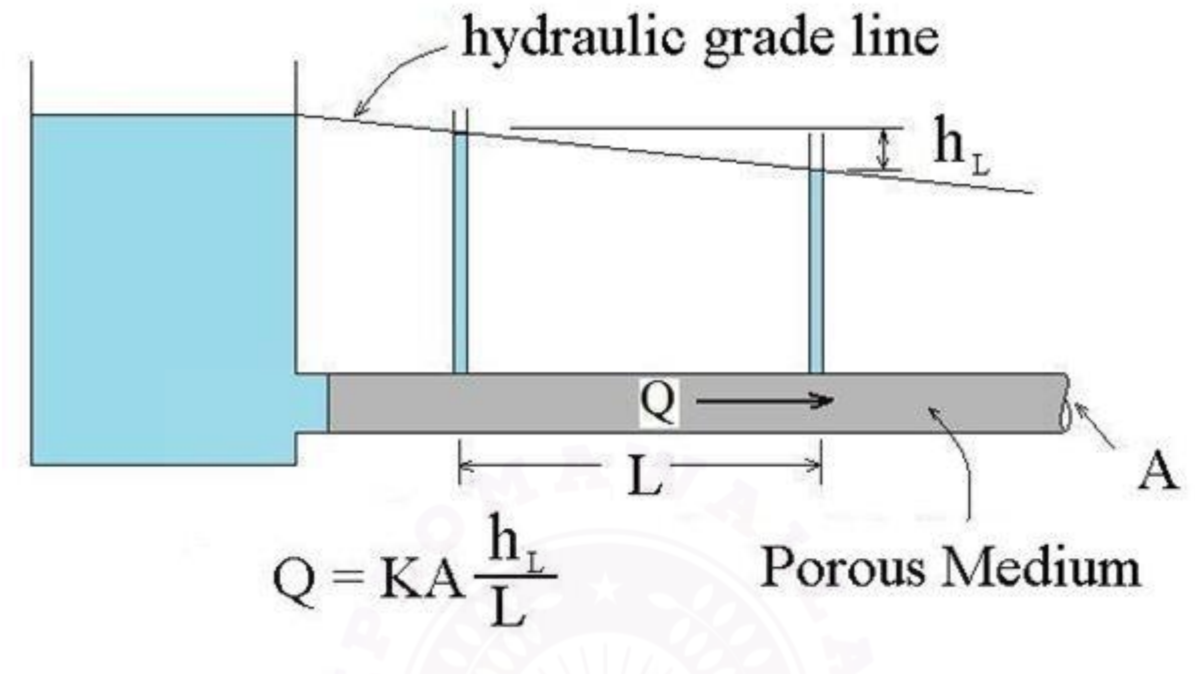
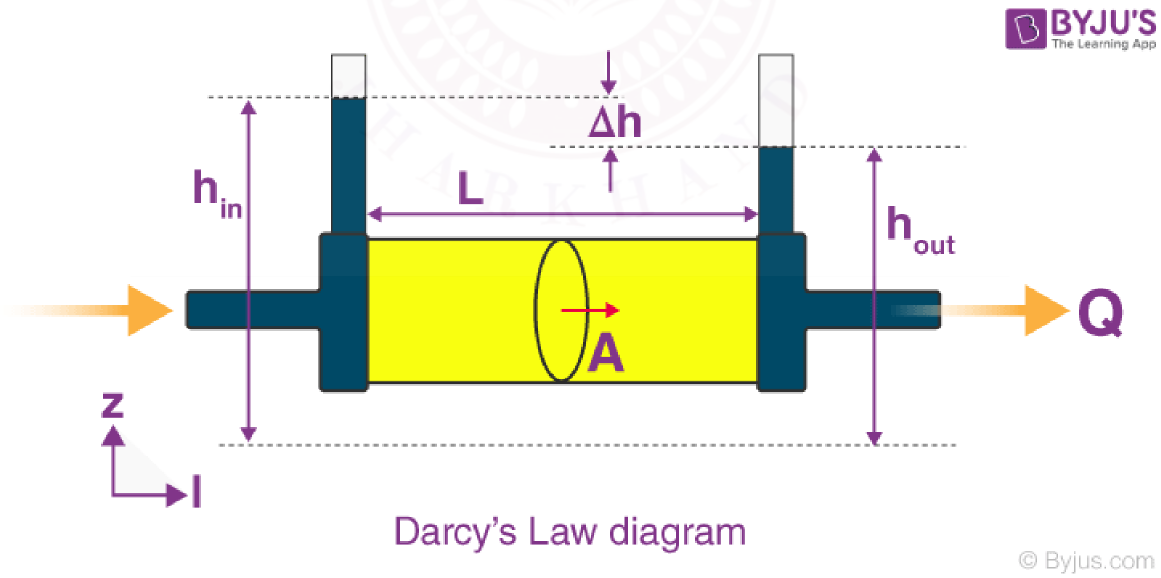
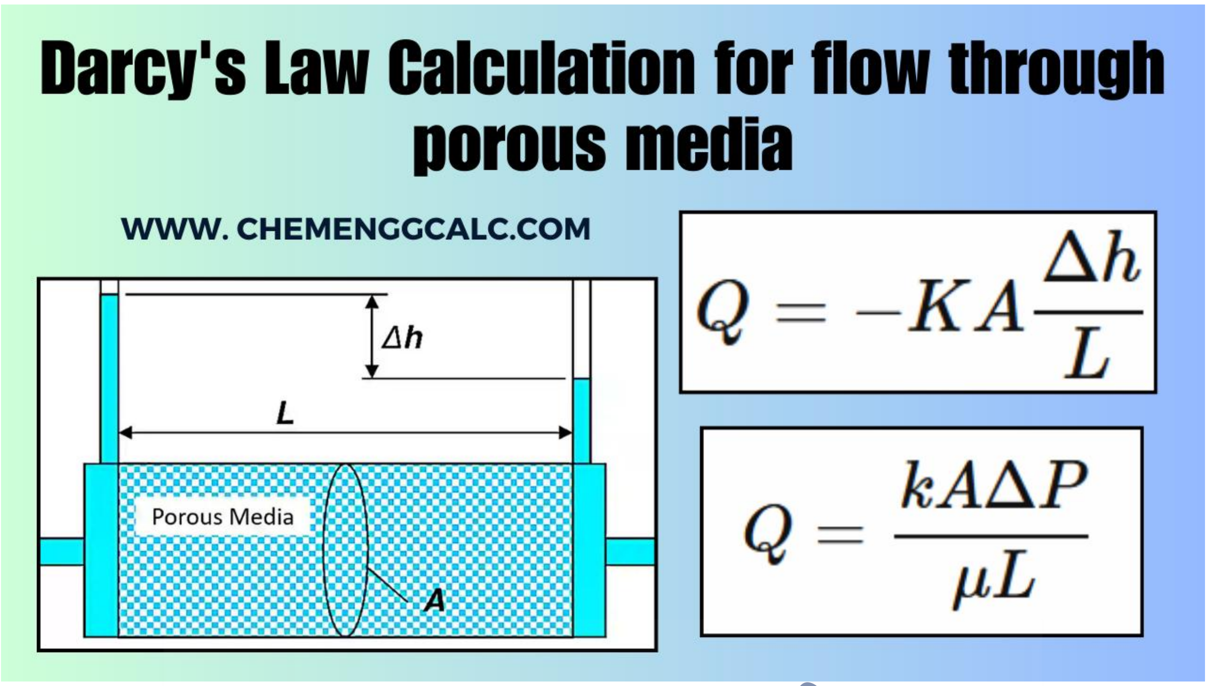
2. Darcy's law of permeability

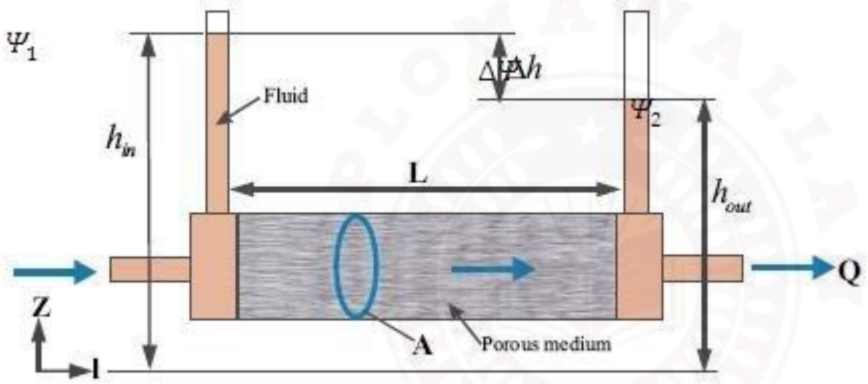


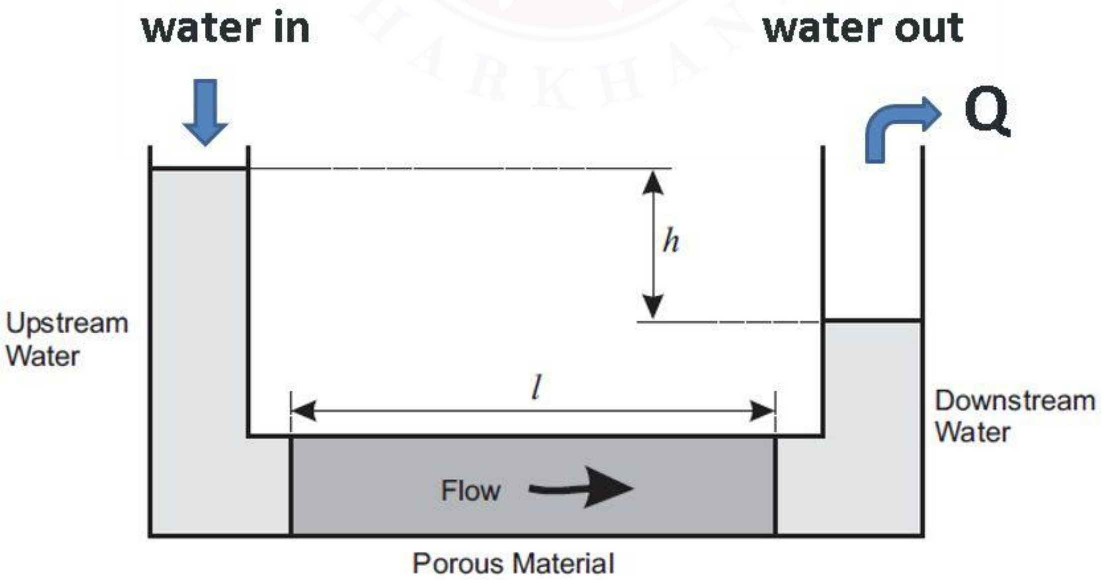
Darcy's Law Apparatus

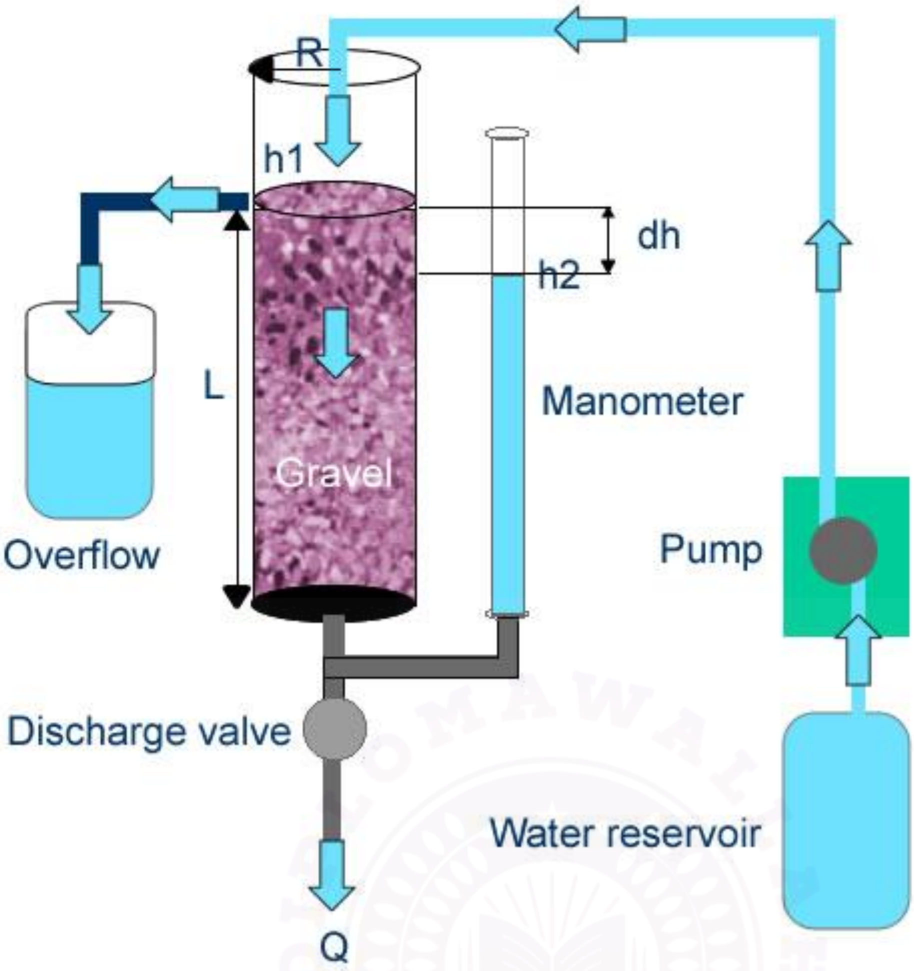


Darcy's Law diagram


Darcy's Law Calculation for flow through porous media
WWW. CHEMENGGCALC.COM
Δh
L
Porous Media
A
$Q = -KA\frac{\Delta h}{L}$
$Q = \frac{kA\Delta P}{\mu L}$


Fluid
L
Q
Z
A
Porous medium


water in
water out
Q
h
Upstream Water
l
Downstream Water
Flow
Porous Material



Statement & Formula:
Henry Darcy (1856) found experimentally that for water flowing through a saturated, homogeneous porous medium under steady laminar flow, the discharge rate is proportional to the hydraulic gradient and the cross-sectional area. The law is commonly expressed as:
[
Q = k ; A ; i
]
where:

- (Q) = volume of water flowing per unit time (m^3/s)
- (k) = coefficient of permeability / hydraulic conductivity (m/s)
- (A) = cross-sectional area normal to flow (m^2)
- (i) = hydraulic gradient = (\dfrac{\Delta h}{L}) (dimensionless) (Wikipedia)

Alternative form (discharge per unit area):
[
q = k,i

]
with (q = Q/A).

Assumptions & Conditions:

- Flow is steady (unchanging with time).
- Flow is laminar (Reynolds number low).
- Soil is saturated, homogeneous, isotropic (or known anisotropy).
- The fluid is incompressible and viscosity constant.
  If these conditions are violated (partial saturation, turbulence, heterogeneous soil) then Darcy's law may not strictly hold. (civilengineeringnotes.com)

Derivation Brief (for exam):

- Darcy's experiments showed (Q ∝ A), (Q ∝ \Delta h), and (Q ∝ 1/L). Combining gives (Q = k A (\Delta h / L)). (TecQuipment)
- The hydraulic gradient (i = \Delta h / L) is the driving force for flow.

Engineering Understanding:

- The term (k) aggregates many influences (soil void structure, connectivity, fluid viscosity).
- If you increase hydraulic gradient ((i)), you increase flow linearly (for given (k)).
- If you increase length of flow ((L)), for same head drop the gradient decreases → less flow (given geometry).
- For a given soil, you can test in lab for (k) and then use Darcy's law in field design (e.g., drainage, seepage through dams, filter design).

Limitations to note:

- Not valid for unsaturated soils (air in voids), or when flow becomes non-laminar. (Elementary Engineering)
- Soil may be anisotropic or stratified → effective (k) may differ in different directions.
- Heterogeneity, preferential paths, secondary voids can invalidate simple Darcy application.

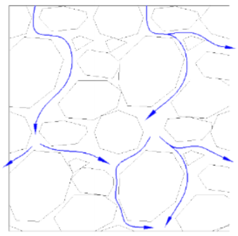
Typical Exam Question Components:

- Ask to state Darcy's law (word + formula).
- Explain meaning of each term and units.
- State assumptions/limitations.

- Possibly apply formula in simple numerical problem (given A, Δh, L, Q find k or vice versa).
- Link to design application (e.g., seepage under dam, drainage of foundation).

3.1 (cont'd) Coefficient of Permeability

Soil type	Permeability k (m/sec)	Reducing permeability
Gravel	>0.1	↓
Sand	$0.1 - 10^{-4}$	
Silt	$10^{-4} - 10^{-8}$	
Clay	$<10^{-8}$	



Description	k (ft/s) [m/s]
Sand	(5.77E-04) [1.76E-04]
Loamy	(5.13E-04) [1.56E-04]
Sandy Loam	(1.13E-04) [3.45E-05]
Silty Loam	(2.36E-05) [7.19E-06]
Loamy	(2.28E-05) [6.94E-06]
Sandy Clayey Loam	(2.07E-05) [6.31E-06]
Silty Clayey Loam	(5.57E-06) [1.70E-06]
Clay Loam	(8.04E-06) [2.45E-06]
Sandy Clayey Loam	(7.11E-06) [2.17E-06]
Silty Clay	(3.34E-06) [1.02E-06]
Clay	(4.21E-06) [1.28E-06]

Soil type	Permeability k (m/sec)	Reducing permeability
Gravel	>0.1	↓
Sand	0.1 – 10^{-4}	
Silt	10^{-4} – 10^{-8}	
Clay	<10^{-8}	

Definition:
The coefficient of permeability (commonly denoted as (k)) is the ratio of the discharge velocity of water through soil under unit hydraulic gradient through a unit cross sectional area. More simply: it is a measure of how easily water can flow through a soil mass under a given driving head. (Fiveable)
In words:

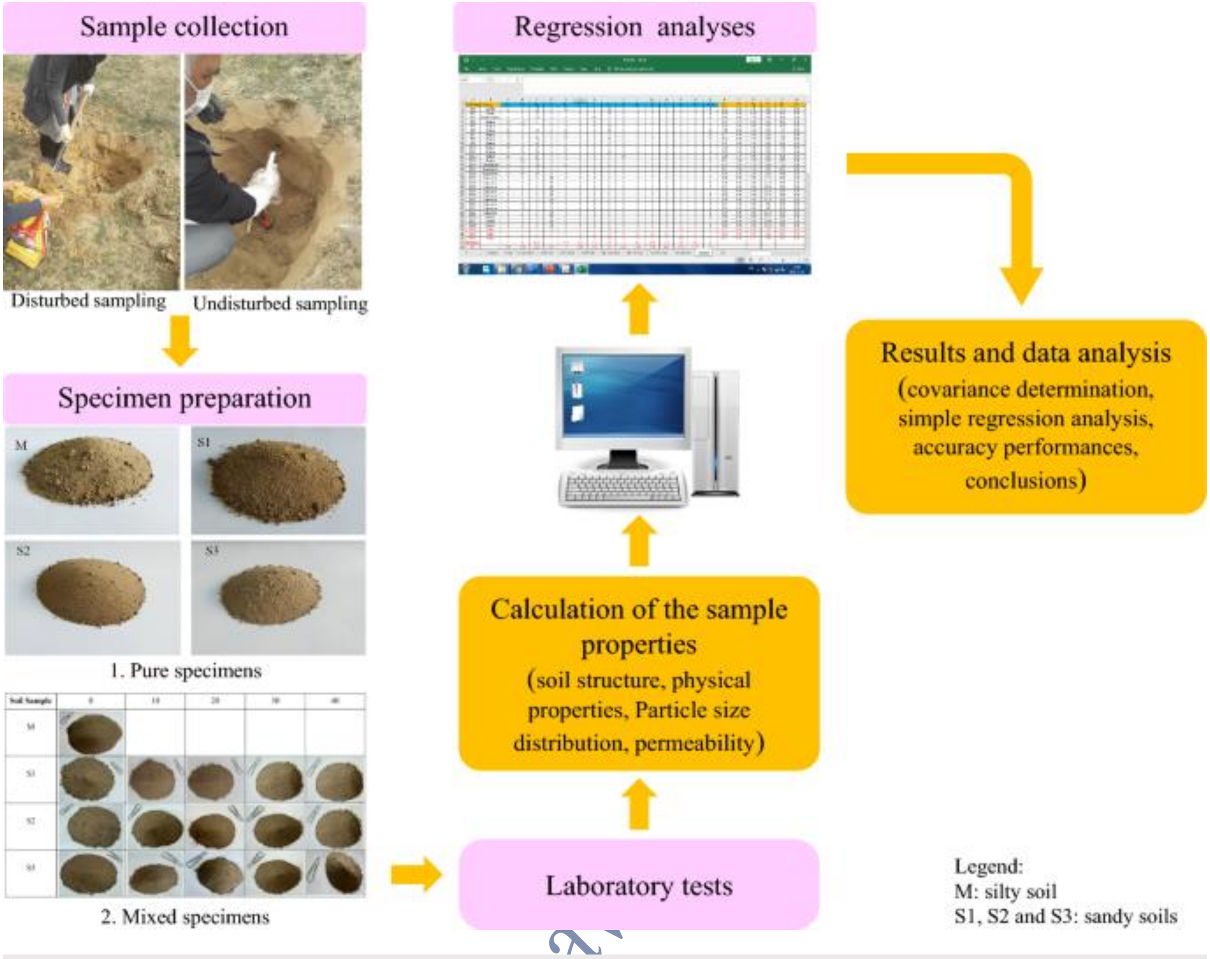
"The coefficient of permeability is a measure of how easily a liquid will move through a soil or rock material." (Fiveable)
Typical units: metres per second (m/s) in SI, sometimes cm/s. (FAOHome)

Interpretation & Importance:

- A higher (k) means the soil allows water to pass through more easily (coarser soils, large voids).
- A lower (k) means the soil resists water flow (fine-grained soils, small voids, less connectivity).
- It is crucial in design for drainage, seepage through dams, foundation settlement, groundwater flow.
- For example, coarse sands might have (k) values many orders of magnitude higher than clays. (Wikipedia)

Relationship with Darcy's Law:
From (q = k , i) where (q) is discharge per unit area and (i) is hydraulic gradient, we see that when (i = 1), (q = k). Thus coefficient of permeability is the specific discharge when gradient = 1. (Elementary Engineering)

3.1 (cont'd) Factors Affecting Permeability



Factors Affecting Permeability of Soils

1. Particle size

The Permeability varies approximately as the square of grain size. It depends on the effective diameter of the grain size (D10)

2. Void ratio

Increase in the void ratio increases the area available for flow hence permeability increases for critical conditions.

3. Properties of pore fluid.

Pore fluids are fluids that occupy pore spaces in a soil or rock. Permeability is directly proportional to the unit weight of pore fluid and inversely proportional to viscosity of pore fluid.

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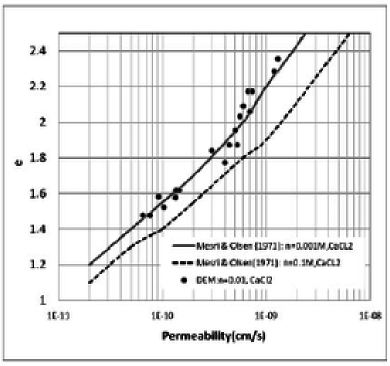
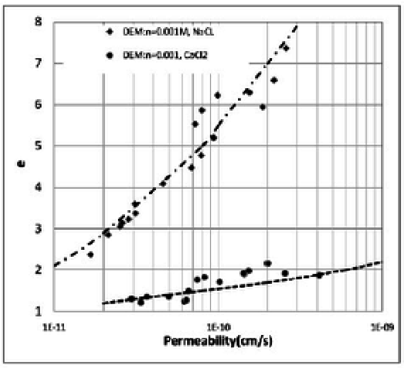
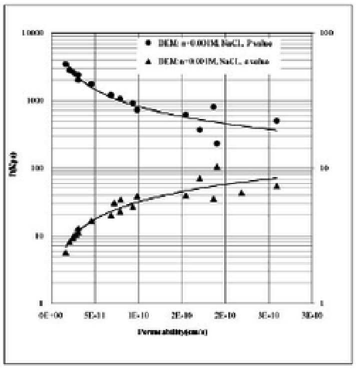






Major influencing factors:

1. **Particle size & gradation**: Larger particles and well-graded coarse soils tend to have larger interconnected voids → higher (k). The relation is often shown as being proportional to square of particle size for coarse soils. (Testbook)
2. **Void ratio (e)**: More void space means more channels for flow; higher (e) → higher (k) (other conditions same). (Wikipedia)
3. **Degree of saturation**: If voids contain air pockets (unsaturated), flow is restricted; fully saturated soil enables higher flow. (Wikipedia)
4. **Particle shape, arrangement, packing and tortuosity**: Irregular shapes, poor packing increase path length; fines/adsorbed water reduce flow. (strataglobal.com)
5. **Fluid properties**: Water viscosity, temperature, density matter; colder water → higher viscosity → lower (k). (sites.lafayette.edu)
6. **Presence of fines, clay minerals, organic matter**: These reduce permeability by clogging voids or reducing connectivity. (Wikipedia)

Exam Tip:
When asked "List factors affecting permeability", mention each factor and a short sentence explaining the influence. If asked "Why does clay have low permeability?" you can answer: small particle size, large specific surface, adsorption of water, non-connected voids → very low (k).

3.1 (cont'd) Determination of Coefficient of Permeability by Constant Head & Falling Head Tests

Constant Head Permeability Test

SOIL PERMEABILITY

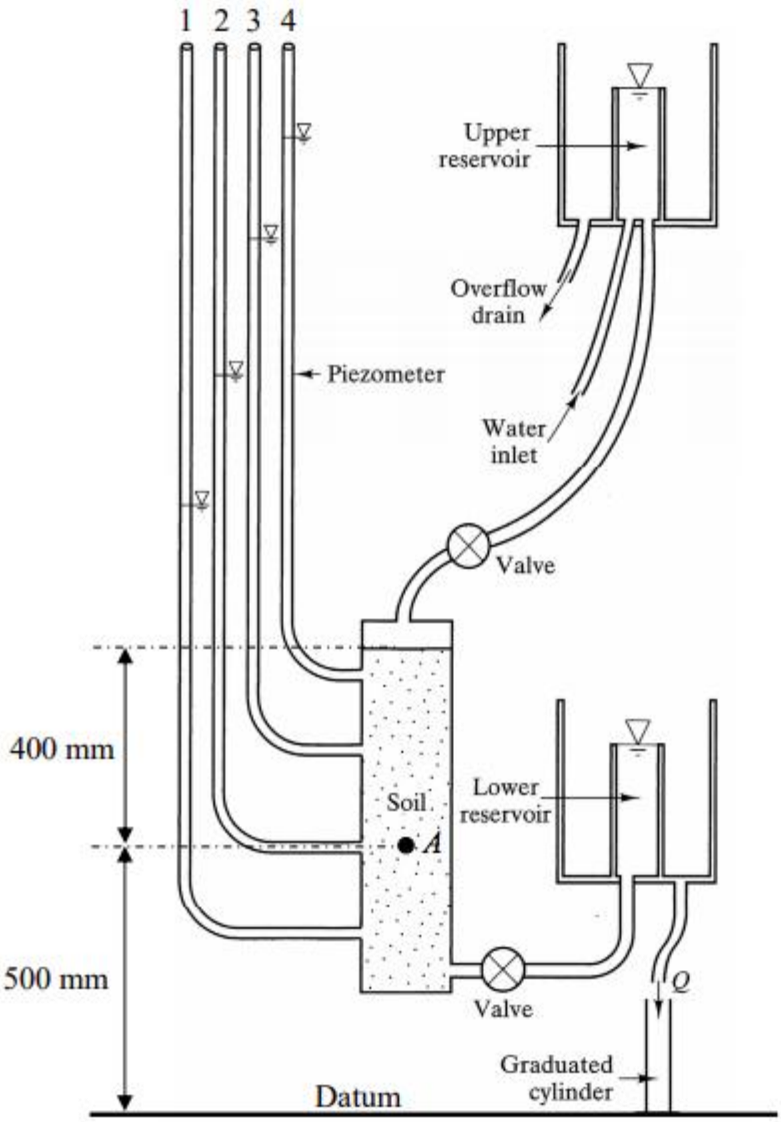


Figure 1 Constant head permeability test.

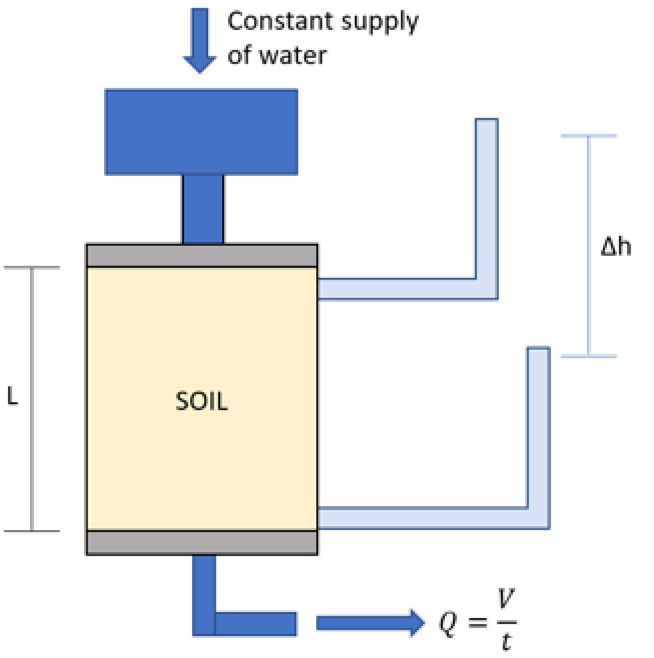


Figure 1: Schematic representation for Constant head Permeability test

$$k = \frac{qL}{Ah}$$

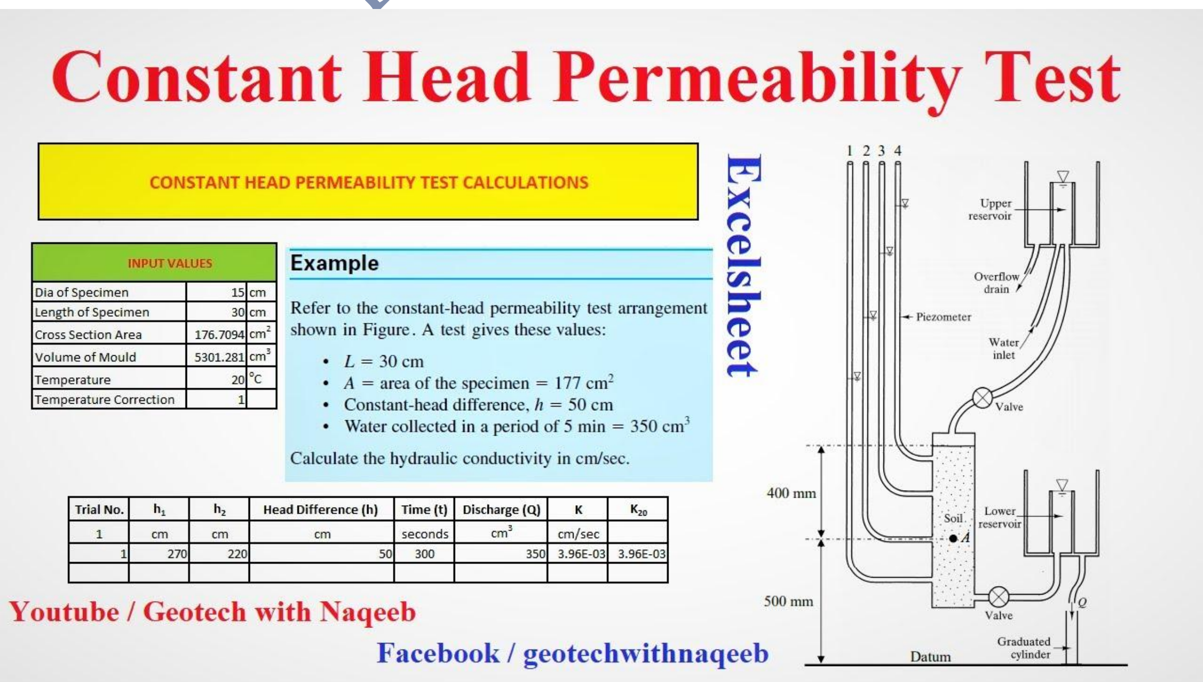
where k = coefficient of permeability in cm/sec

q = Discharge cm^3/sec

L = Length of specimen in cm.

A = Cross-sectional area of specimen in cm^2

H = Constant head causing flow in cm.



INPUT VALUES		
Dia of Specimen	15	cm
Length of Specimen	30	cm
Cross Section Area	176.7094	cm^2
Volume of Mould	5301.281	cm^3
Temperature	20	°C
Temperature Correction	1	

Trial No.	h_1	h_2	Head Difference (h)	Time (t)	Discharge (Q)	K	K_{20}
1	cm	cm	cm	seconds	cm^3	cm/sec	
1	270	220	50	300	350	3.96E-03	3.96E-03

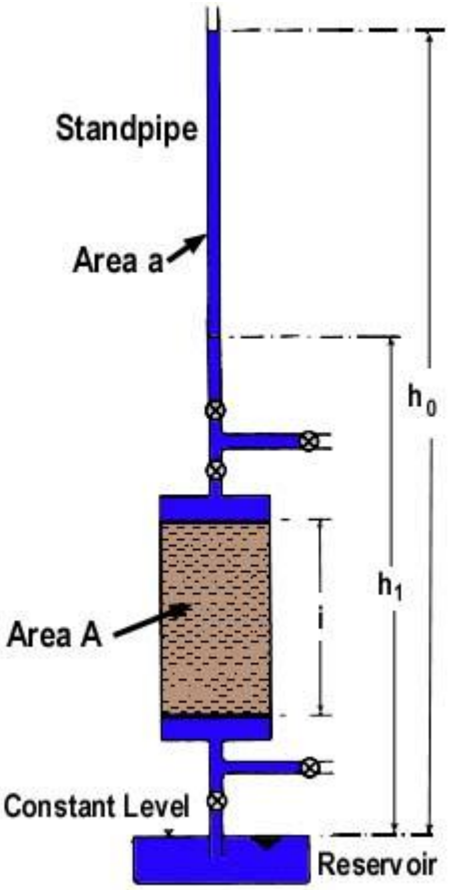
Purpose & Applicability:

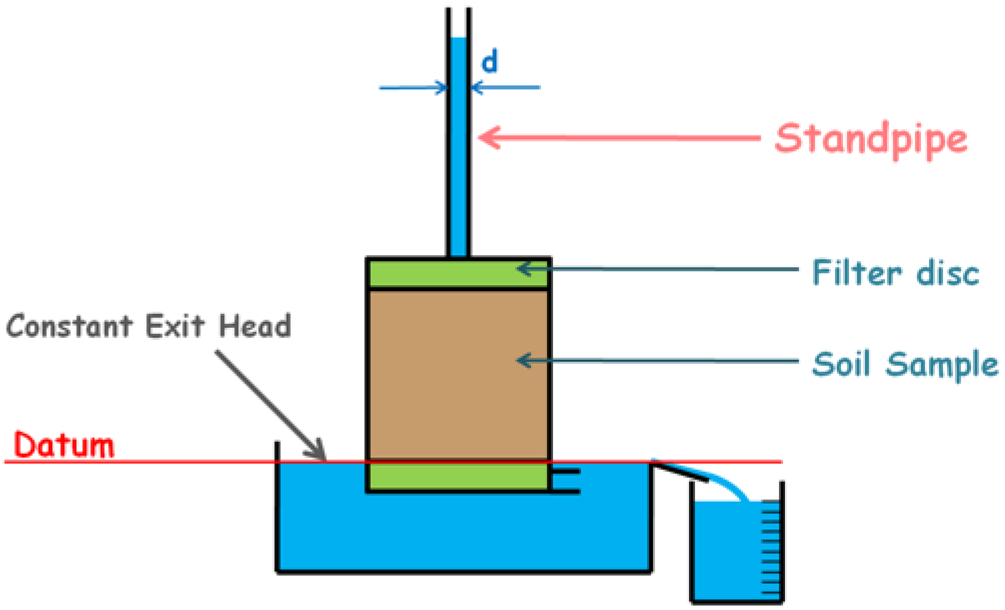
- Suitable for coarse-grained (cohesionless) soils with relatively high permeability. (uta.pressbooks.pub)
  Procedure (brief):
- Prepare soil specimen of known length (L) and cross-section (A), fully saturated. (geotechdata.info)
- Maintain a constant head difference (Δh) across the specimen, allow water to flow steadily through. Collect volume (Q) in time interval (Δt). (geotechdata.info)
  Formula:

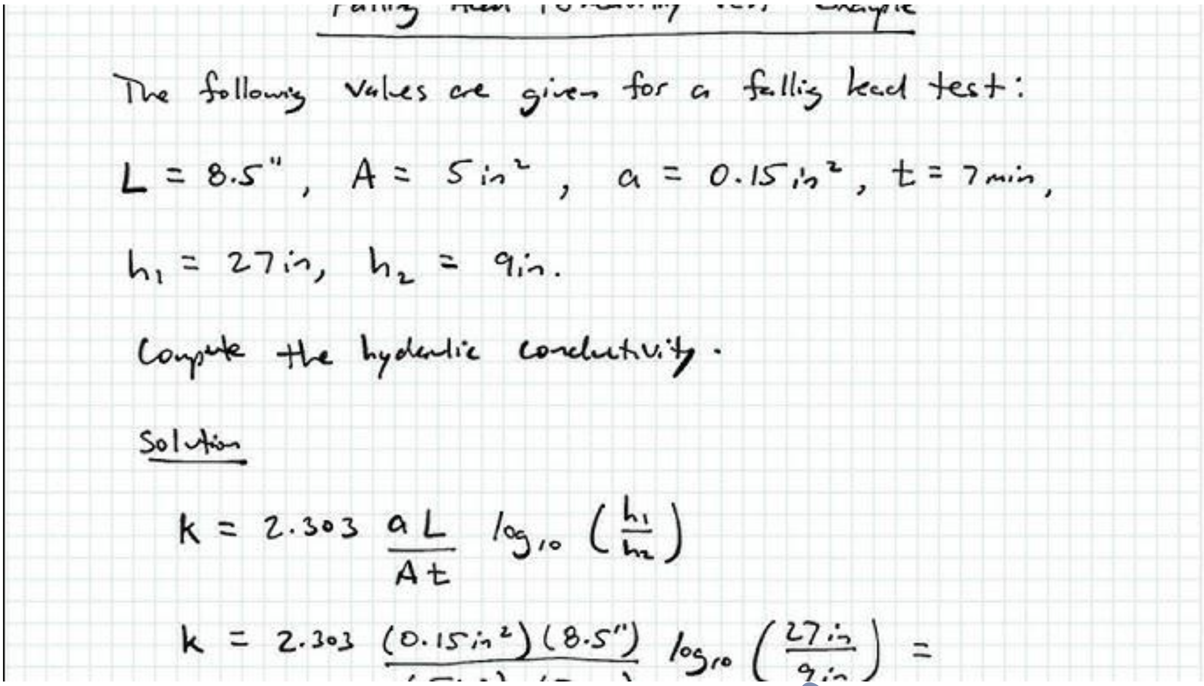
  $$k = \frac{Q \; L}{A \; \Delta h \; \Delta t}$$

  Notes & Conditions:
- Ensure steady state flow is achieved; avoid air in voids; use correct cell dimensions relative to particle size (cell diameter often ≥ 12× largest grain size) to avoid edge effects. (geotechdata.info)
- Good choice when flow is relatively large and easy to measure.

Falling Head Permeability Test


Standpipe
Area a
h0
h1
i
Area A
Constant Level
Reservoir


d
Standpipe
Filter disc
Constant Exit Head
Soil Sample
Datum


Falling Head Permeability Test Example

The following values are given for a falling head test:

$L = 8.5''$, $A = 5\ in^2$, $a = 0.15\ in^2$, $t = 7\ min$,

$h_1 = 27\ in$, $h_2 = 9\ in$.

Compute the hydraulic conductivity.

Solution

$$k = 2.303\ \frac{aL}{At}\ \log_{10}\left(\frac{h_1}{h_2}\right)$$

$$k = 2.303\ \frac{(0.15\ in^2)(8.5'')}{\ldots}\ \log_{10}\left(\frac{27\ in}{9\ in}\right) =$$

$$k = \frac{a \cdot L}{A \cdot t} \cdot \ln \cdot \frac{h_0}{h_t}$$

k = coefficient of permeability (cm / sec)

a = area of burette standpipe (cm^2)

L = length of specimen (cm)

A = area of specimen (cm^2)

t = elapsed time of test (sec)

h_0 = head at beginning (time = 0) of test (cm)

h_t = head at end (time = t) of test (cm)

Purpose & Applicability:

- More suited for fine-grained soils (low permeability) where constant head flow rate would be too slow. (geotechdata.info)
  Procedure (brief):
- A standpipe of cross-section (a) connected to soil specimen of cross-section (A_s) and length (L). The water head drops from (h_1) to (h_2) in time (t). (University of Mustansiriyah)
  Formula:
  [
  k = \frac{a ; L}{A_s ; t} \ln\frac{h_1}{h_2}
  ]
  Notes & Conditions:
- Sample must be fully saturated; volume change negligible. Measurement must be accurate of (\ln(h_1/h_2)). Good for low (k) soils.

Simple Numerical Problem (example format):

Example (for constant head):
Given: soil sample length (L = 0.30 , \text{m}), cross-section (A = 0.01 \text{m}^2), head difference (\Delta h = 0.20 \text{m}), volume collected (Q = 0.00012,\text{m}^3) in time (\Delta t = 60 \text{s}).
Compute (k):
[
k = \frac{0.00012 \times 0.30}{0.01 \times 0.20 \times 60} = \frac{0.000036}{0.120} = 0.0003 ; \text{m/s}
]
You can adapt for falling head style problems similarly.

3.1 (cont'd) Simple Problems to Determine Coefficient of Permeability

When asked in exam:

- Clearly state given data (length, area, head difference/time, volume etc)
- Identify correct formula (constant or falling head) depending on soil type or test description.
- Do careful units conversion (e.g., cm/s to m/s)
- Show calculation steps, write final value with correct units.
- If asked, interpret the value: e.g., "0.0003 m/s implies moderate permeability, typical of fine sand".

Here's a detailed breakdown of **Topics 3.2, 3.3, and 3.4** from your syllabus — with definitions, explanations, diagrams and engineering significance.

3.2 Seepage through earthen structures, seepage velocity, seepage pressure, phreatic line, flow lines, application of flow net

Seepage through Earthen Structures

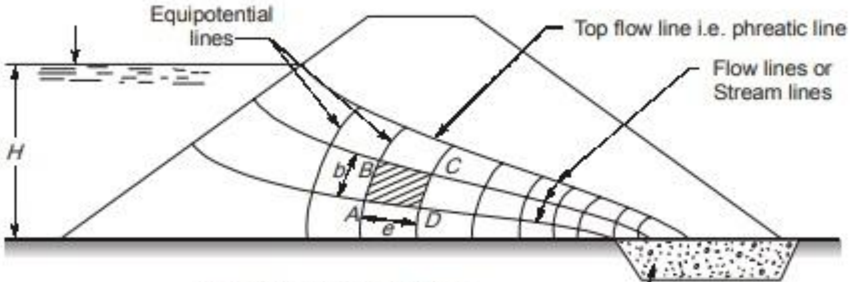
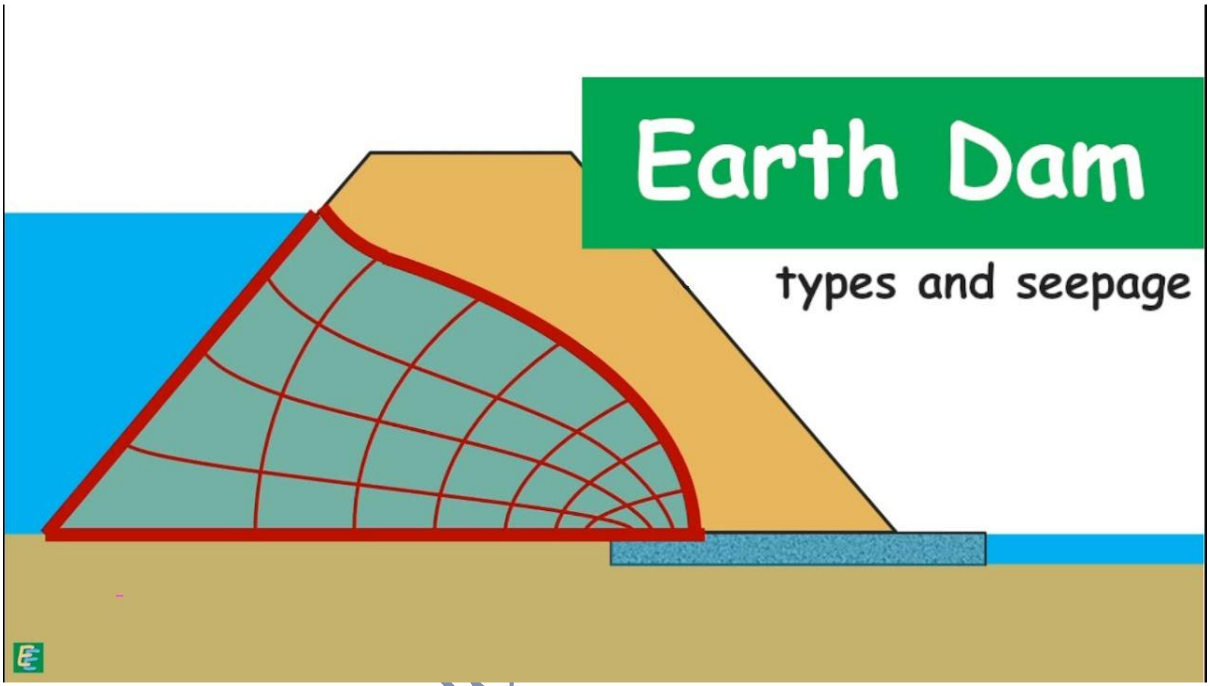
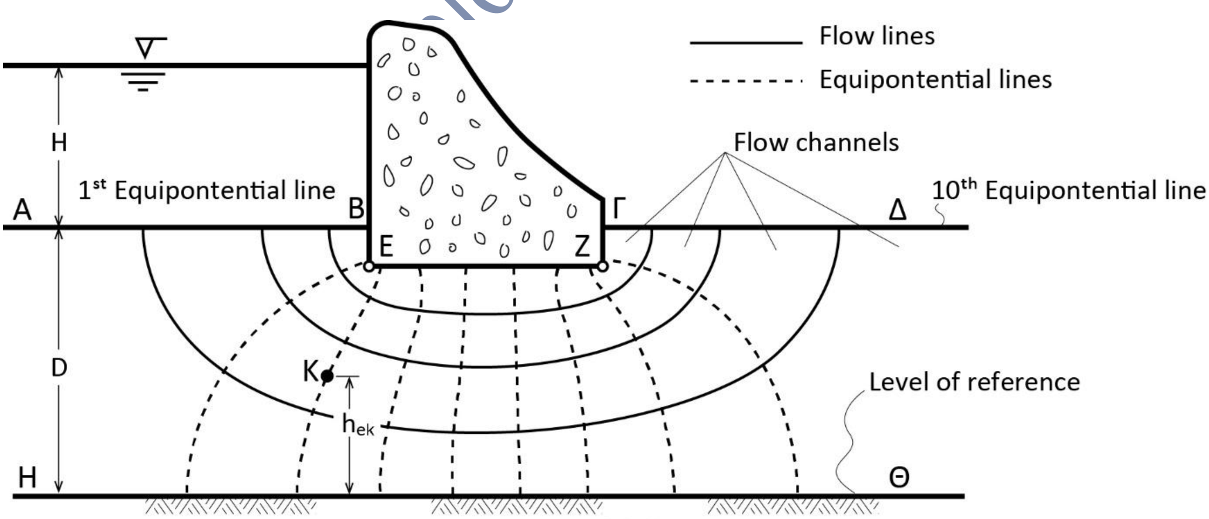
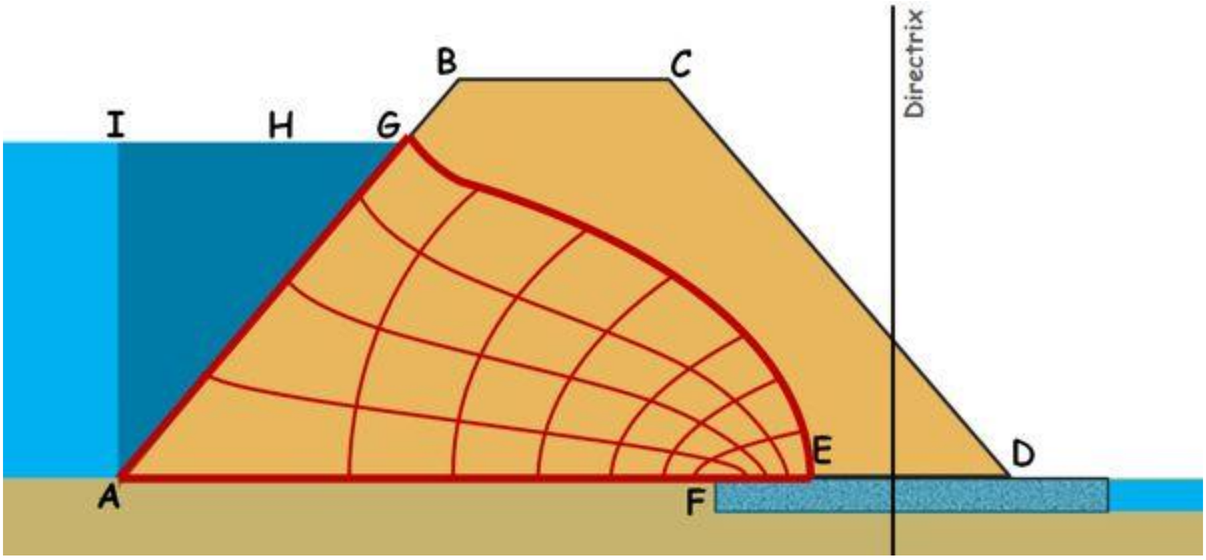
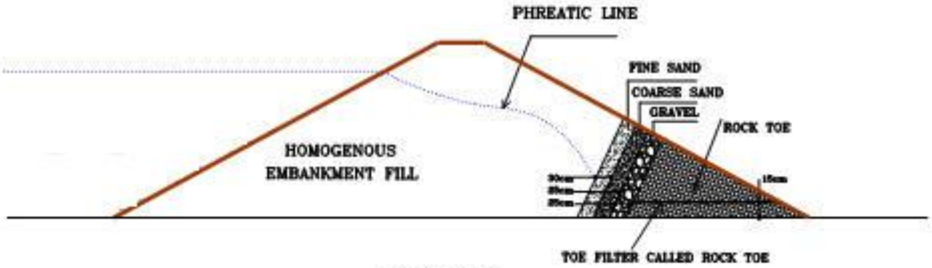


Fig. Section of Earthen Dam

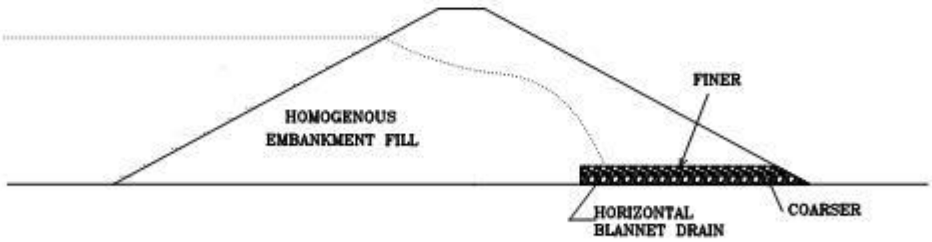




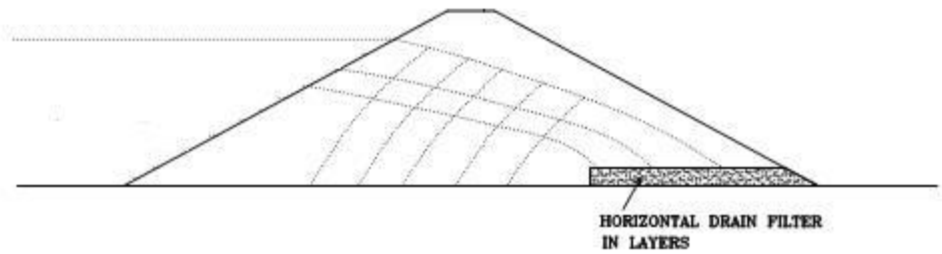




Rock Toe



Horizontal Fillter



Definition & Explanation:
Seepage refers to the movement of water through porous soil media under the influence of a hydraulic (water-head) gradient. In earthen structures (e.g., embankments, earth dams), seepage occurs under or through the structure or its foundation. (publications.usace.army.mil)
In an earth dam, water from the upstream reservoir may enter the body of the dam, travel through the soil mass, and exit downstream. That flow imposes hydraulic forces, pore pressures and may cause internal erosion (piping), uplift or slope instability if not controlled. (EngineeringCivil.org)

Seepage Velocity:
This is the velocity at which water actually moves through the voids of soil, not simply the superficial velocity (flow per unit area). Given a discharge per unit area (q) and porosity (n), the seepage (actual) velocity (v) can be approximated by:

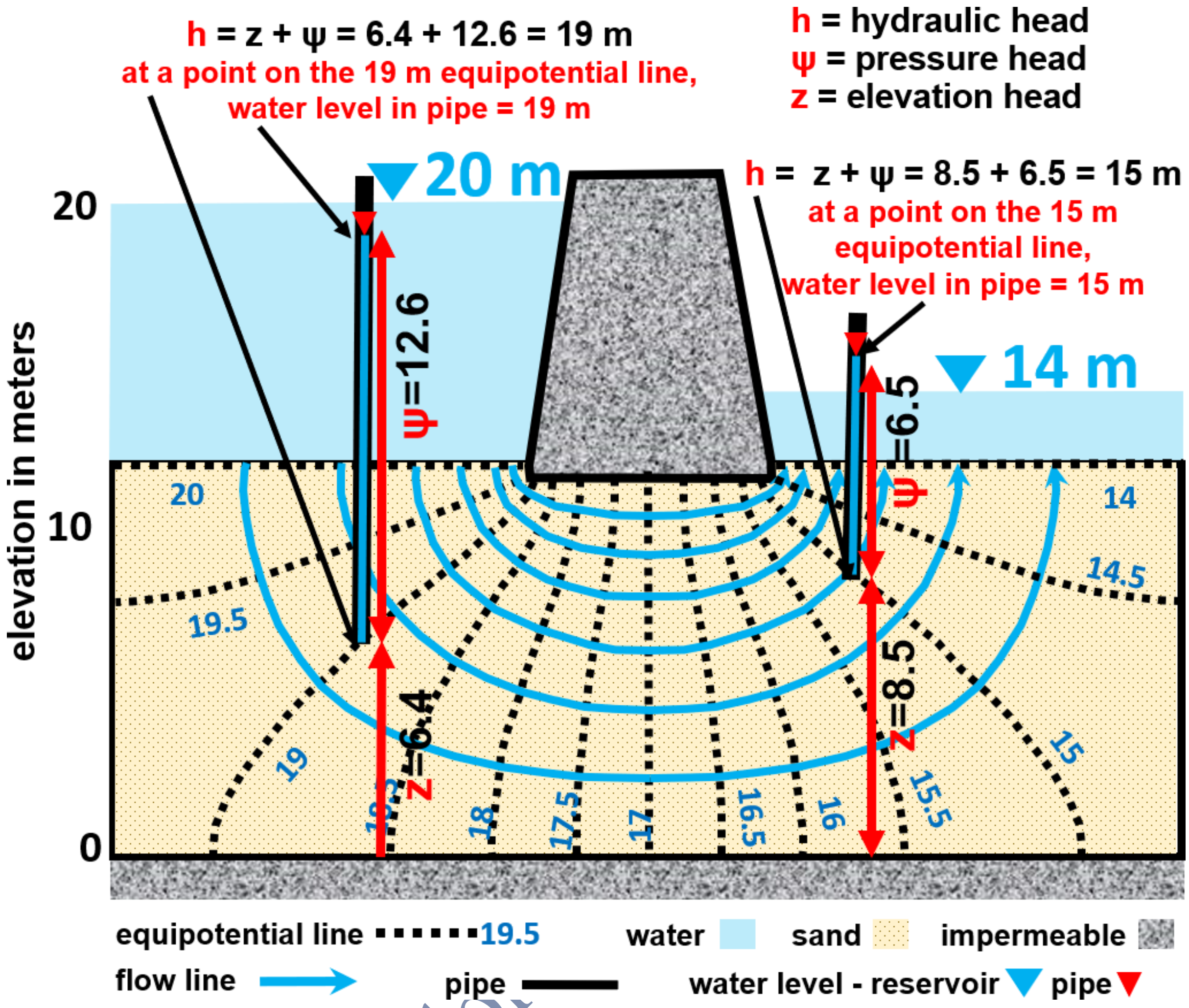
$$v = \frac{q}{n}$$

It shows that although the discharge may appear small, the velocity in the voids can be higher depending on how many voids the water moves through.

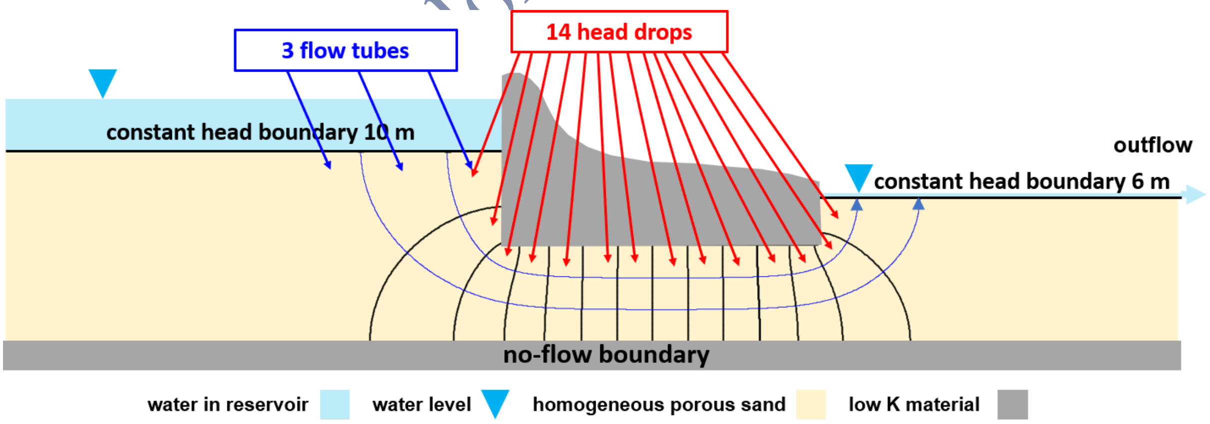
Seepage Pressure:
When water flows through soil, it exerts pore-water pressures on the soil skeleton. These pressures reduce the effective stress in the soil (effective stress = total stress minus pore-water pressure) which in turn reduces shear strength and stability. In earthen structures, high uplift or pore pressure can destabilize slopes or foundations.

Phreatic Line:
In an earth dam or embankment with seepage, the phreatic line is the locus of points in the structure where pore-water pressure is equal to atmospheric pressure; above this line the soil is partially saturated, below it fully saturated. It's important because it separates saturated from unsaturated zones and helps in designing drainage, slope stability, and calculating seepage paths.

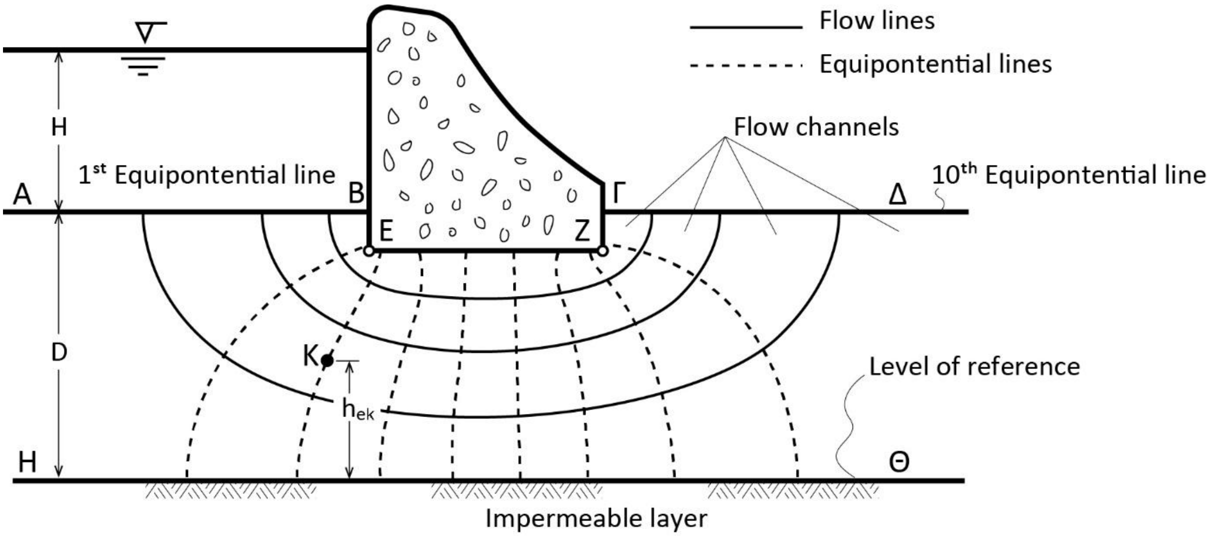
Flow Lines & Application of Flow Net

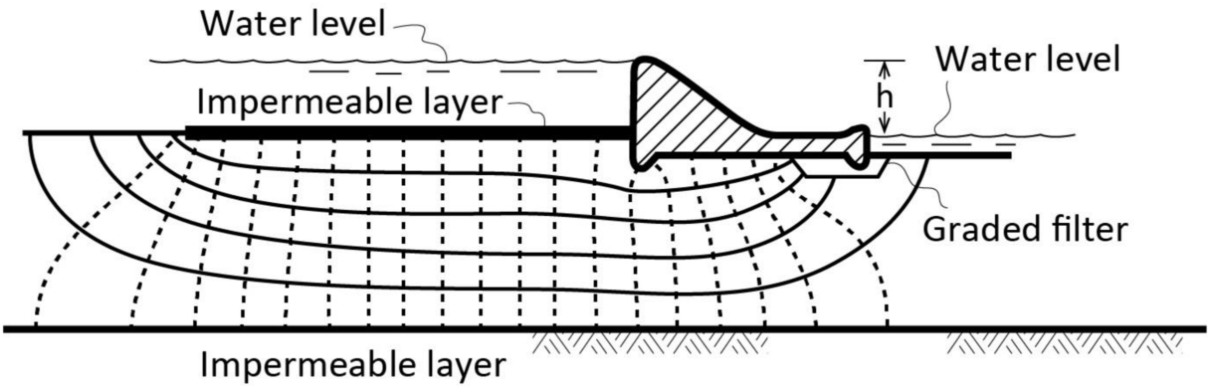


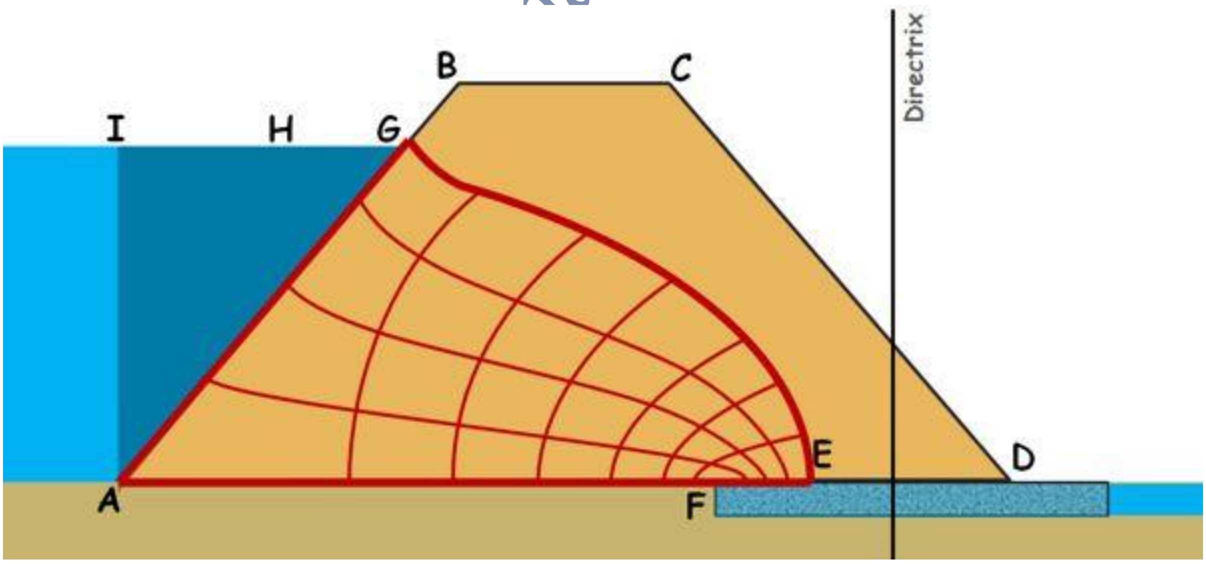
h = z + ψ = 6.4 + 12.6 = 19 m
at a point on the 19 m equipotential line,
water level in pipe = 19 m
h = hydraulic head
ψ = pressure head
z = elevation head
20 m
h = z + ψ = 8.5 + 6.5 = 15 m
at a point on the 15 m
equipotential line,
water level in pipe = 15 m
14 m
ψ=12.6
ψ=6.5
z=6.4
z=8.5
elevation in meters
20
10
0
20
19.5
19
18
17.5
17
16.5
16
15.5
15
14.5
14
equipotential line 19.5
water
sand
impermeable
flow line
pipe
water level - reservoir
pipe

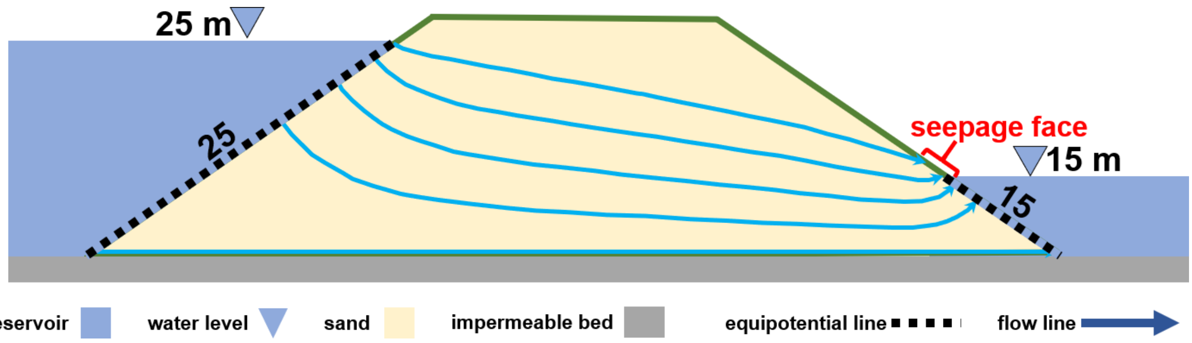


3 flow tubes
14 head drops
constant head boundary 10 m
outflow
constant head boundary 6 m
no-flow boundary
water in reservoir
water level
homogeneous porous sand
low K material


Flow lines
Equipontential lines
Flow channels
H
1st Equipontential line
10th Equipontential line
A
B
Γ
Δ
E
Z
D
K
h_{ek}
Level of reference
H
Θ
Impermeable layer


Water level
Impermeable layer
Water level
h
Graded filter
Impermeable layer


B
C
Directrix
I
H
G
E
D
A
F



A flow net is a graphical tool used to analyse two-dimensional seepage through soils. It consists of:

- **Flow lines**: lines that trace the path that water particles follow through the soil mass.
- **Equipotential lines**: lines along which the total hydraulic head is constant. These two families of lines intersect at nearly right angles and form curvilinear squares or "cells". The construction and interpretation of a flow net are useful to estimate the magnitude of seepage, pore-water pressures, seepage forces and exit gradients. (Fiveable)

Application in Earthen Structures:

- Identify boundary conditions: no-flow boundaries (impervious surfaces), constant head boundaries (reservoir, upstream water level), seepage faces (downstream slope).
- Draw a flow net that satisfies orthogonality and approximate equal spacing of cells.
- From the net count number of flow channels (n_x) and number of equipotential drops (n_γ) to compute discharge:
  [
  Q = k ; \Delta h ; \frac{n_f}{n_d}
  ]
  Where (k) = coefficient of permeability, Δh = head drop between upstream and downstream.
- Determine phreatic line: the location where water surface within the structure equals atmospheric pressure.
- Use net to estimate seepage pressures along flow paths, exit gradients (important for piping risk), uplift pressures under structures, etc.

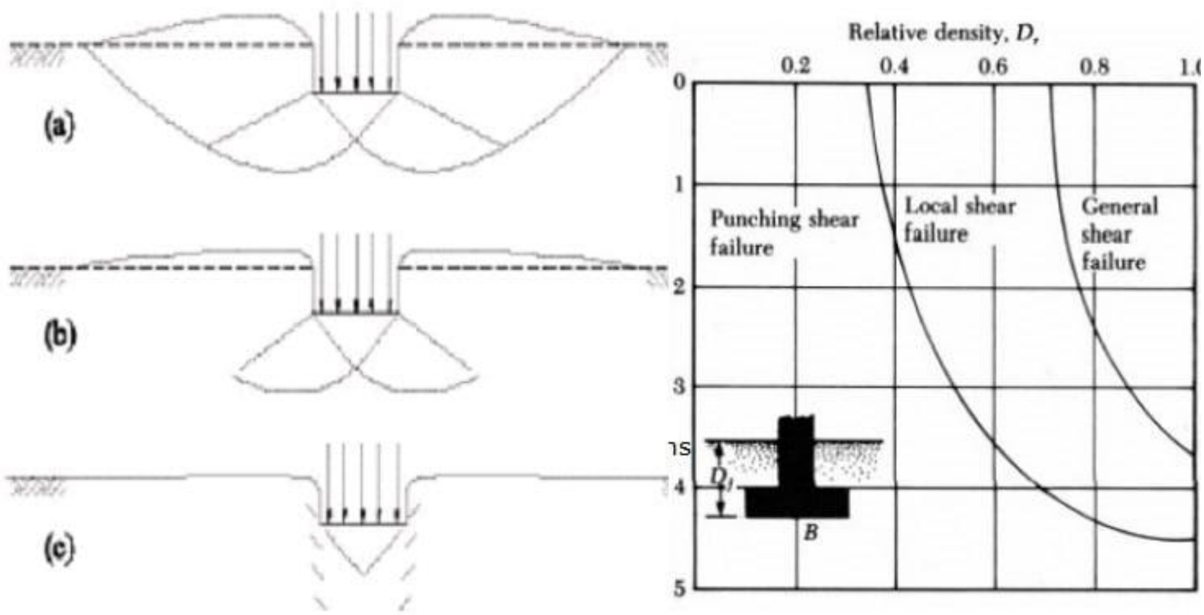
Engineering Significance:

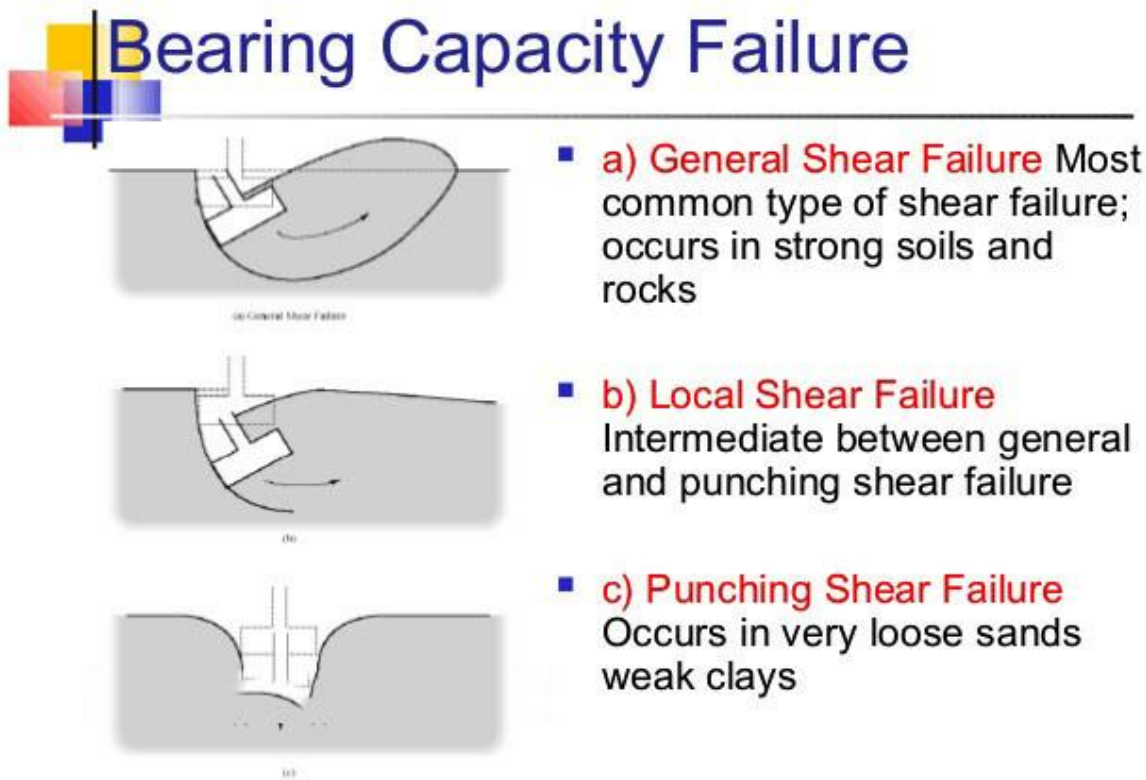
- Seepage un-controlled can lead to *piping* (soil particle movement with water), *uplift* under foundations, *reduction of effective stress*, slope instability.

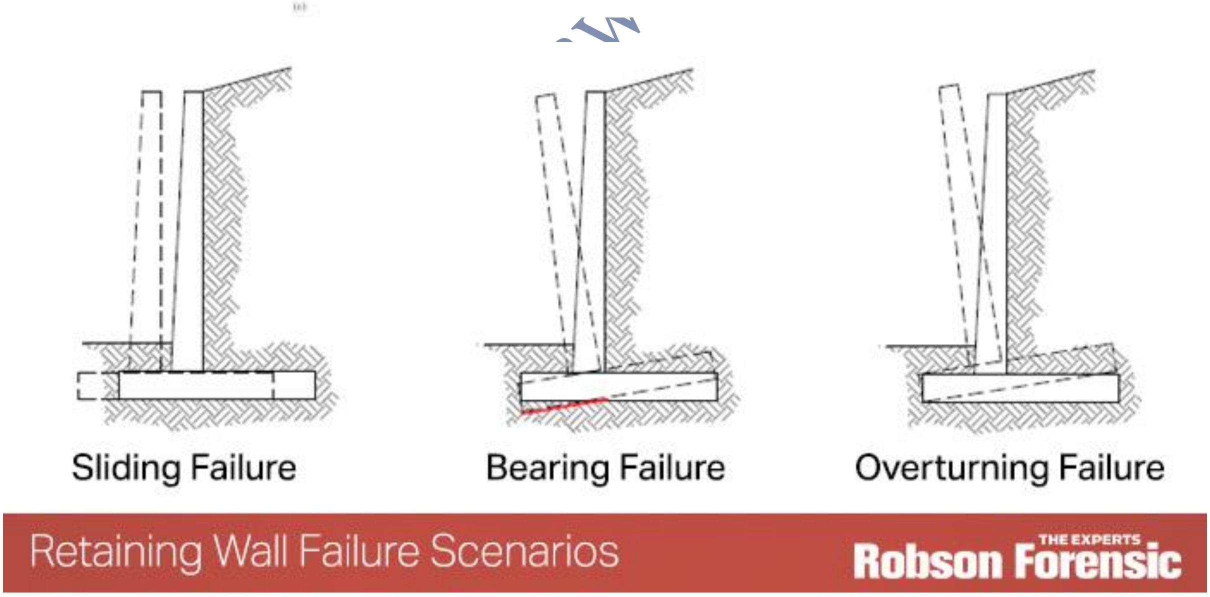
- For earth dams, embankments and retaining structures: knowing seepage paths, phreatic line, velocities helps design appropriate drainage, cutoff walls, filters and stability measures.
- Understanding flow nets allows one to visualize water flow through soil and assess risks and required designs.

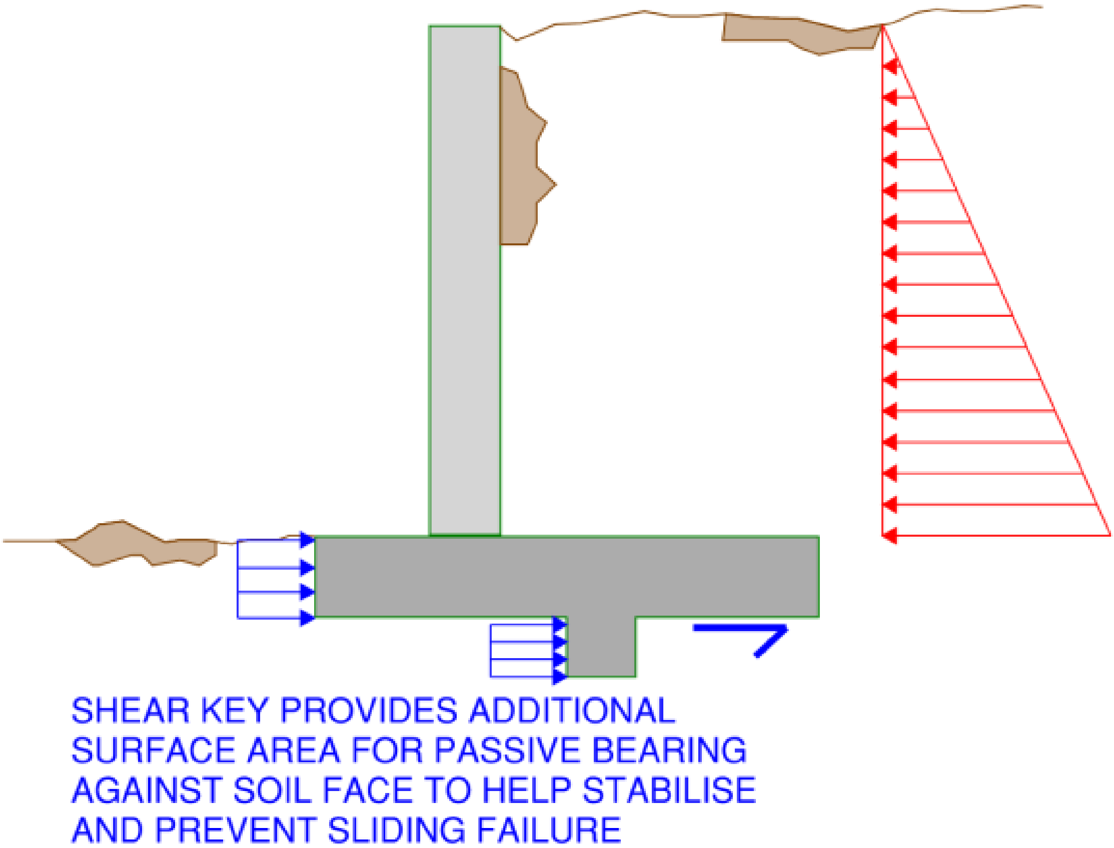
3.3 Shear failure of soil, field situations of shear failure, concept of shear strength of soil, components of shearing resistance of soil – cohesion, internal friction. Mohr-Coulomb failure theory, strength envelope, strength Equation for purely cohesive and cohesionless soils.

Shear Failure of Soil & Field Situations




Bearing Capacity Failure
a) General Shear Failure Most common type of shear failure; occurs in strong soils and rocks
b) Local Shear Failure Intermediate between general and punching shear failure
c) Punching Shear Failure Occurs in very loose sands weak clays


Sliding Failure
Bearing Failure
Overturning Failure
Retaining Wall Failure Scenarios
THE EXPERTS Robson Forensic

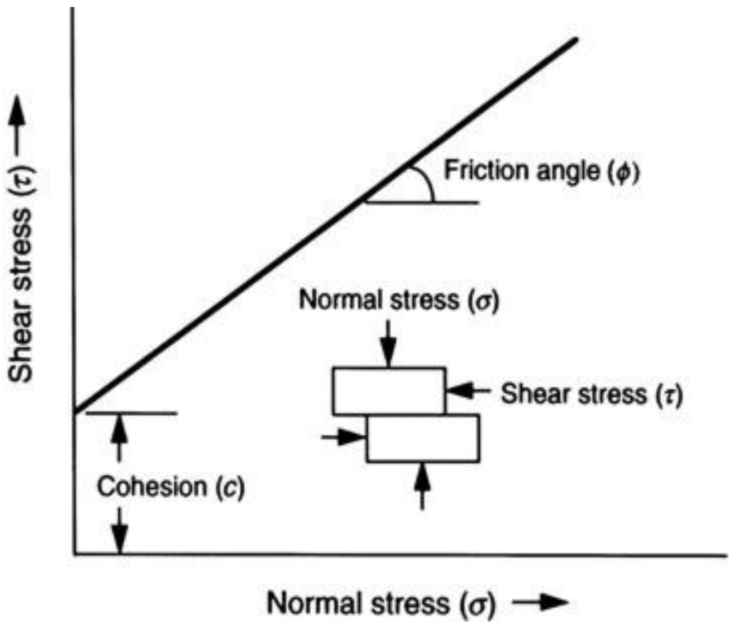


What is Shear Failure?

Shear failure in soils happens when the shear stress along some internal plane in the soil mass exceeds the shear strength of that soil plane. In the field, common examples include:

- Slip of a slope when rainfall or seepage reduces soil strength.
- Bearing capacity failure under foundations when applied stresses exceed soil shear strength.
- Retaining wall lateral failure when lateral earth pressures exceed soil/structure interface or soil shear.
  The soil mass fails along a failure surface and often the phenomenon is dominated by shear.

Concept of Shear Strength of Soil



	Effective Friction Angle, ϕ' (°)		Effective Cohesion, c' (kPa)
	Peak	Residual	
Gravel	34	32	-
Gravel, sandy with few fines	35	32	-
Gravel, sandy with silty or clayey fines	35	32	1.0
Gravel and Sand mixture, with fines	28	22	3.0
Sand, uniform, fine grained	32	30	-
Sand, uniform, coarse grained	34	30	-
Sand, well graded	33	32	-
Silt, low plasticity	28	25	2.0
Silt, medium to high plasticity	25	22	3.0
Clay, low plasticity	24	20	6.0
Clay, medium plasticity	20	10	8.0
Clay, high plasticity	17	6	10.0
Organic Silt or Clay	20	15	7.0

Definition:
Shear strength of a soil is the maximum shear stress that the soil can resist on a failure plane under a given normal effective stress before the soil fails (i.e., begins to deform catastrophically or mobilise large shear displacement).

Components of Shearing Resistance:

1. **Cohesion (c):** A component of shear resistance arising from bonding or inter-particle forces (especially in clays, cemented soils). It is present even when normal stress is zero (in some idealised cases).
2. **Internal friction (φ, angle of internal friction):** Resistance arising from friction and interlocking between soil particles when sliding along a plane. Represents how the normal stress contributes to shear resistance via ($\tan\varphi$).

Mohr-Coulomb Failure Theory & Strength Envelope

Theory:
The Mohr-Coulomb failure criterion provides a linear relationship between shear strength and normal effective stress for soils:

$$\tau = c + \sigma' \tan\phi$$

Where:

- (τ) = shear strength on failure plane
- (c) = effective cohesion intercept
- (σ') = effective normal stress on the failure plane (total normal stress minus pore-water pressure)
- (ϕ) = angle of internal friction. (rocscience.com)

Strength Envelope:
When Mohr circles representing principal stresses at failure are plotted on a shear stress ((τ)) vs normal stress ((σ)) diagram, the straight line tangent to these circles is the failure envelope (strength envelope). Its intercept on the (τ)-axis is (c), its slope is ($\tan\phi$). (ResearchGate)

Special Cases:

- *Purely cohesive soil*: Here ($\phi \approx 0°$) so ($\tau = c$). Thus, shear strength is essentially constant regardless of normal stress.
- *Cohesionless soil*: Here ($c \approx 0$), so ($\tau = \sigma' \tan\phi$). Shear strength arises entirely from internal friction.

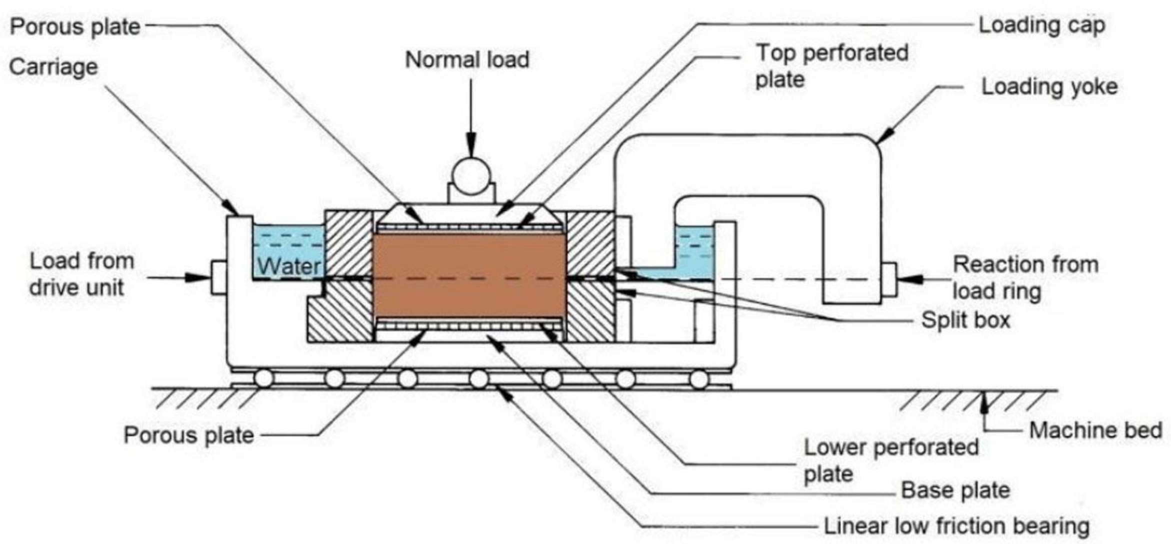
Engineering Significance

- The parameters (c) and (ϕ) are fundamental in geotechnical design: bearing capacity, slope stability, retaining wall design, ground improvement.
- Effective stress concept is crucial: pore-water pressure reduces (σ') → reduces (τ) capacity.
- Knowing how shear strength varies with normal stress allows engineers to evaluate safety under different loading and environmental conditions.

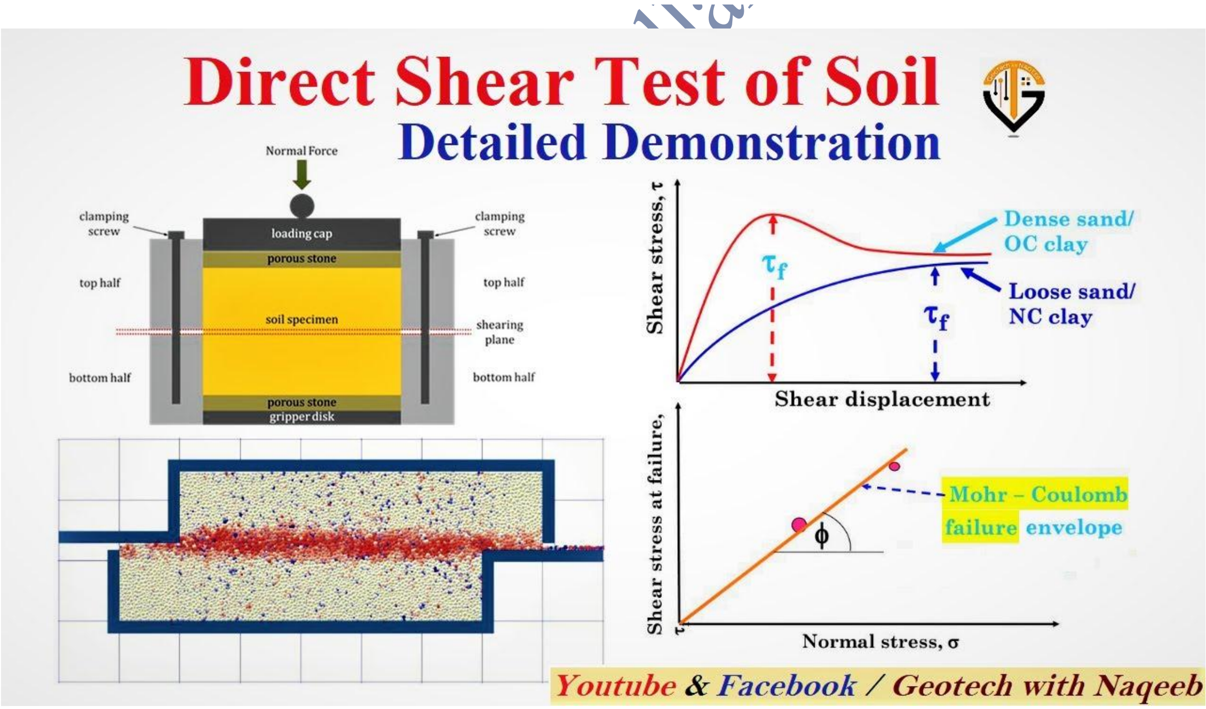
- Understanding field situations of shear failure helps in diagnosing failure mechanisms and designing remedial measures (drainage, reinforcement, reduction of load, etc).

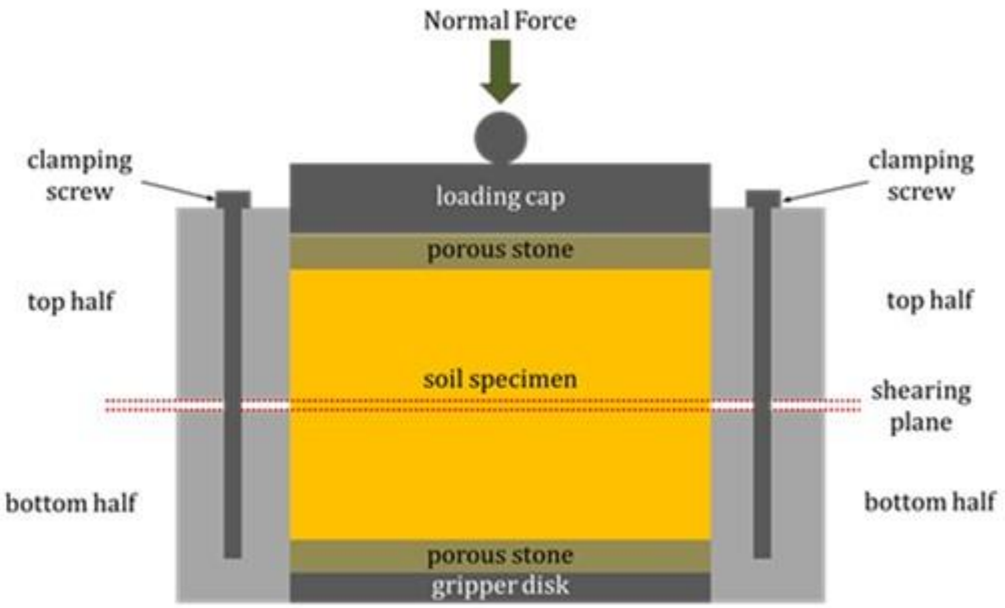
3.4 Laboratory Methods: Direct Shear Test, Vane Shear Test (Numerical on direct shear test only)

Direct Shear Test



Typical setup for a direct shear test


Direct Shear Test of Soil
Detailed Demonstration
Normal Force
clamping screw
clamping screw
loading cap
porous stone
top half
top half
soil specimen
shearing plane
bottom half
bottom half
porous stone
gripper disk
Shear stress, τ
Dense sand/ OC clay
Loose sand/ NC clay
τ_f
τ_f
Shear displacement
Shear stress at failure, τ
Mohr – Coulomb failure envelope
ϕ
Normal stress, σ
Youtube & Facebook / Geotech with Naqeeb



Purpose:
To determine the shear strength parameters ((c) and (\phi)) of a soil by subjecting a soil specimen to a normal stress and then shearing it along a predetermined plane until failure occurs.

Procedure (overview):

- A soil sample of known area is placed in a shear box apparatus.
- A normal load (normal stress) is applied to the sample.
- The sample is allowed to consolidate under that normal stress (if required).
- A horizontal (shear) force is applied at a constant rate until the specimen fails (or reaches a specified large displacement).
- Shear force at failure is recorded; shear stress is computed (shear force divided by area).
- This process is repeated for different normal stresses; shear stress vs normal stress data are plotted; the strength envelope is derived to give (c) and (\phi). **Numerical problems** in exams typically involve computing shear stress, plotting envelope, finding (c) and (\phi).

Vane Shear Test

Purpose & Scope:

- The vane shear test is used mainly for relatively soft, undisturbed cohesive soils (clays) to estimate undrained shear strength (S_u).
- A four-bladed vane is inserted into the soil and rotated at a constant rate until a failure happens along a cylindrical surface around the vane. The torque required is measured and related to shear strength.
  Note: While the direct shear test is used for numerical problems in your

syllabus, knowledge of the vane shear test procedure, its applicability, limitations and result interpretation is still required.

Diploma Wallah

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