Soil Water potential

$\Psi_T = \Psi_g + \Psi_p + \Psi_m + \Psi_o$

Ψ_T = Total water potential.

Ψ_g = gravitional potential.

Ψ_p = pressure potential.

Ψ_m = matric potential

Ψ_o = Osmatic potential neglect

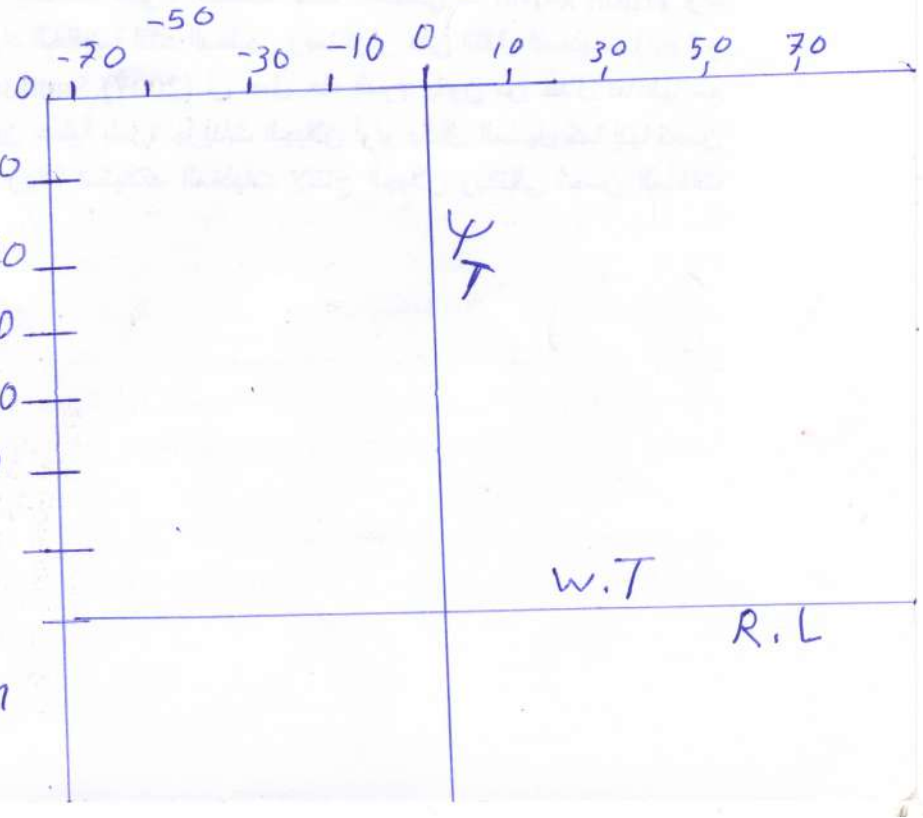
Ψ_g
- \+ above positive
- R.L = 0 refrence Level
- \- under negative

- Ψ_m above water table. negative (unsaturated soil)
- W.T
- Ψ_p under water table. positive (saturated soil)

Soil moisture is at equilibrium with ground water which 70 cm depth from the surface. calculate gravitational potential and total potential along depth of soil profile. (The refrence Level be in the 70cm depth frome the surface). If you get atable of soil depth and matric potential, Then draw its curve

depth / cm	0	10	20	30	40	50	60	70
matric potetial	-70cm	-60	-50	-40	-30	-20	-10	0

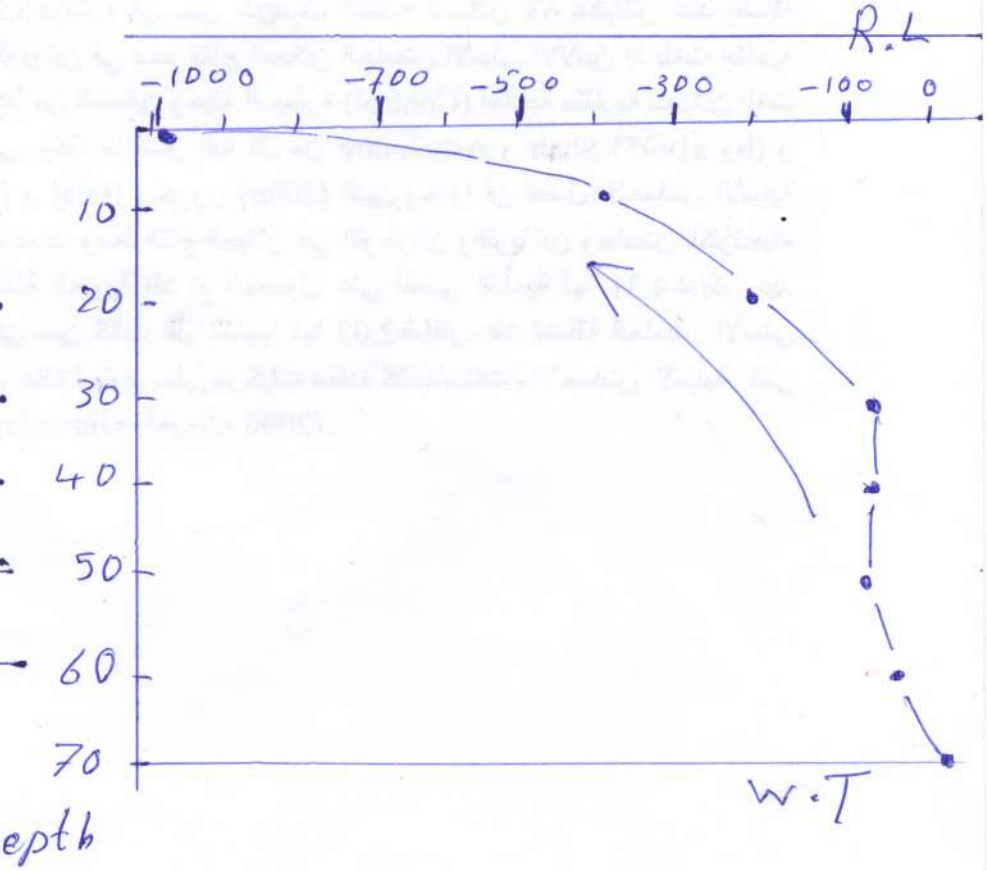
Ψ_p	Ψ_m	Ψ_g	Ψ_T
0	-70	+70	0
0	-60	60	0
0	-50	50	0
0	-40	+40	0
0	-30	30	0
0	-20	20	0
0	-10	10	0
0	0	0	0



The water evaporation from soil surface and the refrence Level be in the soil surface. The matric potential be respectively with the the depth of soil profile in this table. calculate total potential with draw its curve.

Depth cm	0	10	20	30	40	50	60	70 cm
Ψ_m cm	-1000	-390	-180	-70	-60	-50	-30	0 cm

Ψ_p	Ψ_m	Ψ_g	Ψ_T
0	-1000	0	-1000
0	-390	-10	-400
0	-180	-20	-200
0	-70	-30	-100
0	-60	-40	-100
0	-50	-50	-100
0	-30	-60	-90
0	0	-70	-70



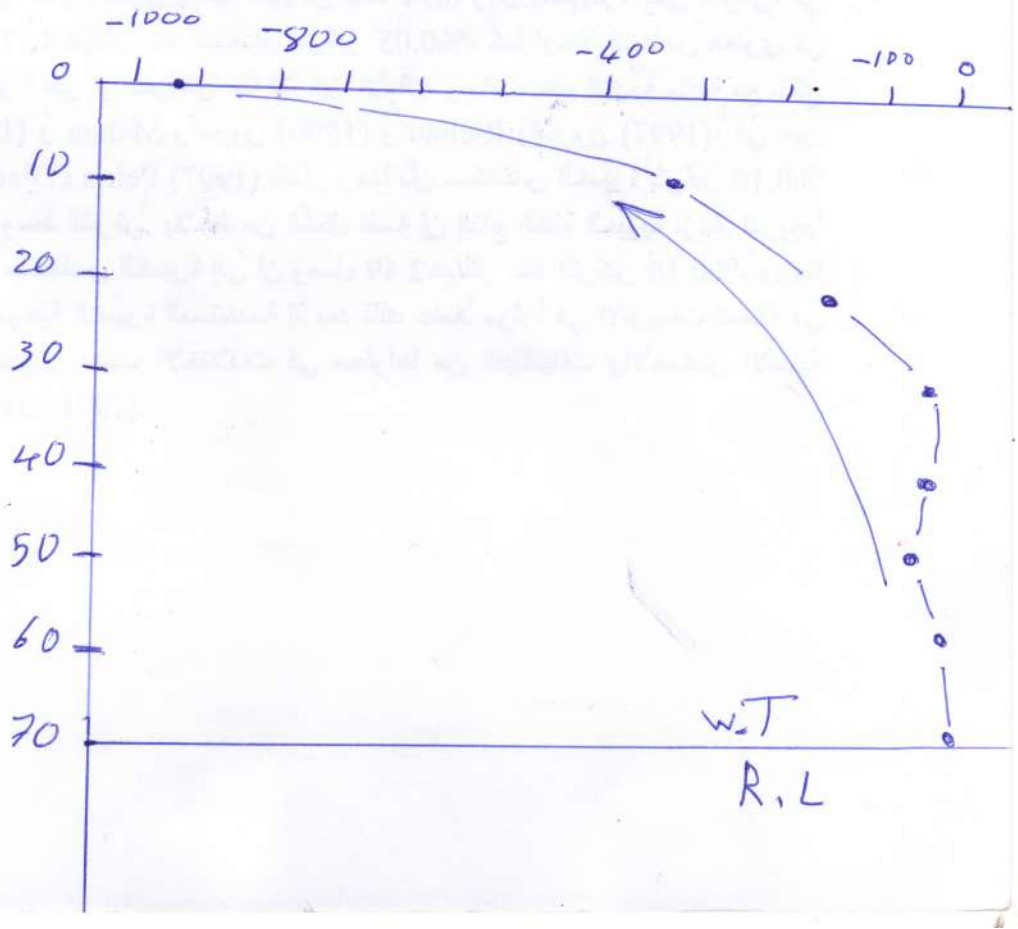
water table be 70 cm depth

Example

The water evaporation from soil surface and (the water table and refrence Level be in 70 cm depth from the surface). The matric potential be respectively with the depth of soil profile in this table. calculate total potential with draw its curve.

Depth cm	0	10	20	30	40	50	60	70	cm
Ψ_m cm	-1000	-390	-180	-70	-60	-50	-30	0	cm

Ψ_p	Ψ_m	Ψ_g	Ψ_T
0	-1000	+70	-930
0	-390	+60	-330
0	-180	+50	-130
0	-70	+40	-30
0	-60	+30	-30
0	-50	+20	-30
0	-30	+10	-20
0	0	0	0

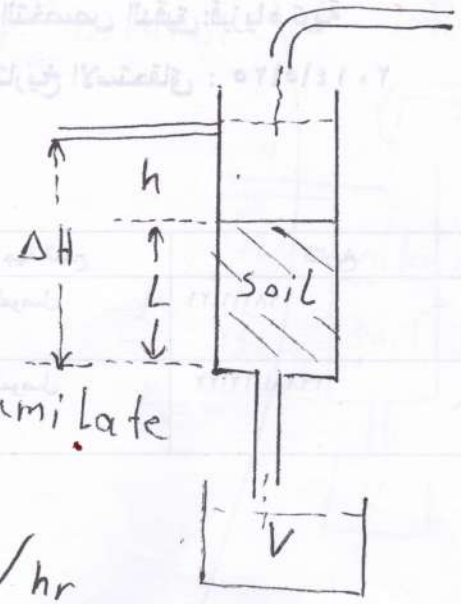


1. Saturated hydraulic conductivity --- k
Darcy's Law — constant head

The volume of water per unit time throught the soil column is directly proportion with (the cross. sectional area of soil) change of hydraulic head and inversely proportion with the Length of soil.

$$\frac{V}{t} \propto \frac{A\ \Delta H}{L}$$

$\frac{V}{t} \Rightarrow Q$



V volum of water acumilate

t time

Q discharge rate cm^3/hr

h hydraulic head

ΔH change of hydraulic head cm

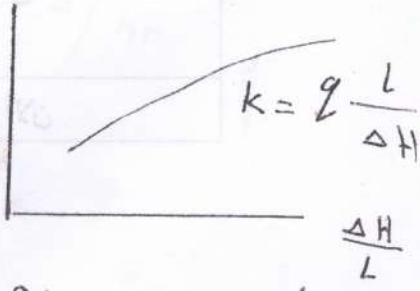
L Length of soil column

$\frac{\Delta H}{L}$ hydraulic gradient تدرج الجهد الهيدروليكي

$$Q = \frac{V}{t} = k A \frac{\Delta H}{L}$$

$$q = \frac{V}{At} = k \frac{\Delta H}{L}$$

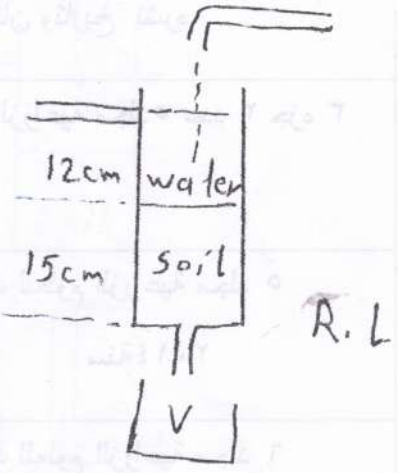
$$k_s = q \frac{L}{\Delta H}$$



q flux cm/hr

6

The length of soil column 15 cm and diameter cross section 11.25 cm (rediuse = 5.62 cm) or cross section area 100 cm^2. The ~~length~~ height of water above the soil surface 12 cm. The water accumilaties at the base of the column 500 cm^3 during 2hr. calculate the saturated hydraulic conductivity ~~of~~ in vertical column. if R-L at base of columne.



h_p	h_g	h_T	
+12	+15cm	+27cm	A
x	x	x	B

$$\Delta H = h_{in} - h_{out}$$
$$A \quad B$$

$$\Delta H = 27 - 0 = 27 cm$$

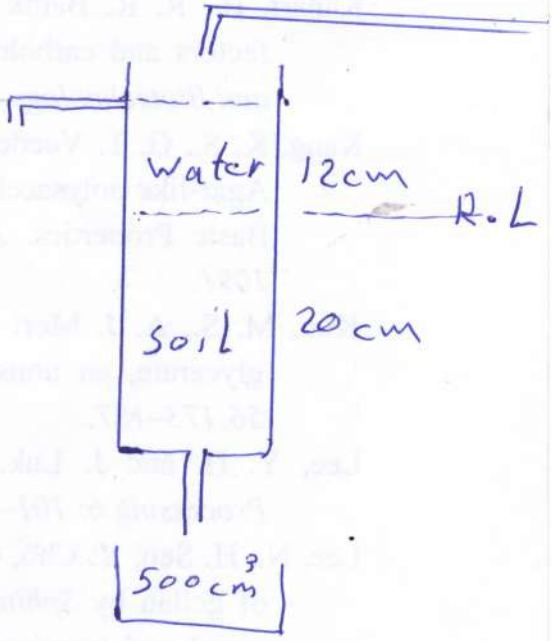
$$k_s = \frac{V}{At} * \frac{L}{\Delta H}$$

$$k_s = \frac{500\ cm^3}{100\ cm^2} \quad \frac{15\ cm}{2hr} \quad \frac{15\ cm}{27\ cm} = 1.38\ cm/hr$$

Example

The length of soil column 20 cm and cross section area 100 cm^2. The height of water above the soil surface 12 cm. The water accumilaties at the base of the column 250 cm^3 during one hours. calculate the saturated hydraulic conductivity if refrence level at soil surface.

h_p	h_g	h_T
+12	0	+12
0	-20	-20



$$\Delta H = h_{in} - h_{out}$$

$$\Delta H = +12 - (-20) = +32 \text{ cm}$$

$$k_s = \frac{V}{At} \frac{L}{\Delta H}$$

$$k_s = \frac{500 \text{ cm}^3}{100 \text{ cm/hr}} \frac{20 \text{ cm}}{32 \text{ cm}} = 3.12 \text{ cm/hr}$$

saturated hydraulic conductivity

Soil physics

1- mathematical relationships of components

2 - soil texture

3- Soil structure

4- Soil consistency

5- Bulk density

6- Soil crusting , Modulus of rupture.

7- Tension unite.

8 – Soil water potential .

9 - saturated hydraulic conductivity.

Mathematical relationships of components

<table>
<tr><td colspan="3">Volume</td><td></td><td colspan="2">Mass</td></tr>
<tr><td rowspan="3">Vt</td><td rowspan="2">Vf</td><td>Va</td><td>Air</td><td>Ma=0</td><td rowspan="3">Mt</td></tr>
<tr><td>Vw</td><td>Water</td><td>Mw</td></tr>
<tr><td></td><td>Vs</td><td>Solid</td><td>Ms</td></tr>
</table>

1- Particle density ρs :

$$\rho s = \frac{Ms}{Vs}$$

Is expresses the ratio of the mass of dried particles to the volume of soil participles.

In most soils , the mean density of the soil particles is about 2.6 -- 2.7 gm/cm^3 average 2.65 gm/cm^3 .

2-Dry bulk density (Bulk density) :-

$$\rho b = \frac{Ms}{Vt} = \frac{Ms}{Vs+Va+Vw} =$$

The dry bulk density expresses the ratio of the dried particles mass to the total volume of soil .

It is obviously smaller than the value of particle density.

3-Porosity:-

$$f = \frac{V_f}{V_t} 100 = \frac{V_w + V_a}{V_S + V_a + V_w} 100$$

Porosity: - is an index of the soil pores volume relates to the soil total volume .

Generally porosity in the rang 30- 60 % . Coarse textured soils tend to be less porous than fine textured soils .

4-Void ratio (e):-

$$e = \frac{V_f}{V_s} 100 = \frac{V_W + V_a}{V_s} 100$$

The void ratio :- is an index of soil pores volume relates to the volume of solids .

5-Mass Wetness:-

$$\theta_m = \frac{M_w}{M_s} 100$$

Mass Wetness :-Is the mass of water relative to mass of dry soil particles. Unit : gm / gm

6-Volume Wetness :-

$$\boldsymbol{\theta v} = \frac{\boldsymbol{Vw}}{\boldsymbol{Vt}} \mathbf{100} = \frac{V_w}{V_S + V_f} 100$$

Volume Wetness : percentage of water volume to the total volume of the soil .

7- **Degree of saturation :-**

$$\boldsymbol{\theta s} = \frac{\boldsymbol{Vw}}{\boldsymbol{Vf}}\mathbf{100} = \frac{\boldsymbol{V_W}}{\boldsymbol{V_a + V_w}}\mathbf{100}$$

Degree of saturation : Index expresses the volume of soil water relative to the volume of soil pores. Unit :- cm^3/cm^3

8-Air filled porosity :-

$$\mathbf{f_a = \frac{Va}{Vt}100 = \frac{Va}{Vs+Vw+Va}100}$$

Air filled porosity :-Index expresses the volume air pores relative to the total volume of the soil . unite: cm^3/cm^3.

prove the right equale the left

$$f = \theta_v + f_a$$

$$= \frac{V_w}{V_t} + \frac{V_a}{V_t} = \frac{V_w + V_a}{V_t} = \frac{V_f}{V_t}$$

$$f_a = f\,(1 - \theta_s) = \frac{V_f}{V_t}\left(1 - \frac{V_w}{V_f}\right) = \frac{V_f}{V_t}\left(\frac{V_f - V_w}{V_f}\right)$$

$$= \frac{V_a}{V_t}$$

$$\theta_v = f - f_a$$

$$= \frac{V_f}{V_t} - \frac{V_a}{V_t} = \frac{V_f - V_a}{V_t} = \frac{V_w}{V_t}$$

$$f = \frac{e}{1+e} = \frac{\frac{V_f}{V_s}}{1 + \frac{V_f}{V_s}} = \frac{\frac{V_f}{V_s}}{\frac{V_s + V_f}{V_s}} = \frac{V_f}{V_t}$$

$$e = \frac{f}{1-f} = \frac{\frac{V_f}{V_t}}{1 - \frac{V_f}{V_t}} = \frac{\frac{V_f}{V_s}}{\frac{V_t - V_f}{V_t}} = \frac{V_f}{V}$$

$$\theta_s = \frac{\theta_v}{f} = \frac{\frac{V_w}{V_t}}{\frac{V_f}{V_t}} = \frac{V_w}{V_f}$$

$$\theta_v = \theta_m \frac{\rho_b}{\rho_w}$$

(6)

$$= \frac{M_w}{M_s} \frac{\frac{M_s}{V_t}}{\frac{M_w}{V_w}} = \frac{V_w}{V_t}.$$

$$f = 1 - \frac{\rho_b}{\rho_s}$$

$$= 1 - \frac{\frac{M_s}{V_t}}{\frac{M_s}{V_s}} = 1 - \frac{V_s}{V_t} = \frac{V_t - V_s}{V_t} = \frac{V_f}{V_t}$$

$$\rho_b = (1-f)\rho_s$$
$$= \left(1 - \frac{V_f}{V_t}\right) \cdot \frac{M_s}{V_s}$$
$$= \left(\frac{V_t - V_f}{V_t}\right) \frac{M_s}{V_s} = \frac{M_s}{V_t}$$

Mathematical Relationships of soil components

Q1. A sample of the soil its wet weight is 1000 g its volume is 640 cm^3 dried in the oven to 800 gm weight. calculate bulk density, volume wetness, porosity, void ratio, mass wetness degree of saturation and air filled porosity

1) $\rho_b = \frac{M_s}{V_t} = \frac{800}{640} = 1.25$ gm/cm^3

$M_w = M_t - M_s$

$= 1000 - 800 = 200$ gm $= 200$ cm^3 $\rho_w = \frac{M_w}{V_w}$

2) $\theta_v = \frac{V_w}{V_t} 100$

$= \frac{200}{640} 100 = 31.2\ \%$

$\rho_s = \frac{M_s}{V_s}$

$V_s = \frac{800}{2.65} = 302$ cm^3

$V_f = V_t - V_s$

$= 640 - 302 = 338$ cm^3

3) $f = \frac{V_f}{V_t} 100 = \frac{338}{640} 100 = 52\ \%$

(8)

(4) $e = \frac{V_f}{V_s} 100 = \frac{338}{302} 100 = 1.12\ \%$

$\theta_m = \frac{M_w}{M_s} 100 = \frac{200}{800} 100 = 25\ \%$

(5) $\theta_s = \frac{V_w}{V_f} 100$

$= \frac{200}{338} 100 = 60\ \%$

$V_a = V_f - V_w$

$= 338 - 200 = 138\ cm^3$

$f_a = \frac{V_a}{V_t} 100$

$= \frac{138}{640} 100 = 21\ \%$

$f = \left(1 - \frac{\rho_b}{\rho_s}\right) 100 = \left(1 - \frac{1.25}{2.65}\right) 100 \simeq 52\ \%$

$\theta_v = \theta_m \frac{\rho_b}{\rho_w} = 25 \frac{1.25}{1} = 31.25\ \%$

$f = \theta_v + f_a$

$= 31.2 + 21 = 52.2\ \%$

(9)

Q. - If you have asample of soil in form of cubic lenght, width and depth (10 * 10 * 10 cm). it is wet weight is 1460 gm and it's dry weight 1200g and its particle density is 2.65 g/cm³ calculate. θ_m . θ_v . ρ_b . f . fa

$M_w = M_t - M_s$

$= 1460 - 1200 = 260\ gm = 260\ cm^3$ $\quad M_w = V_w$

① $\theta_m = \frac{M_w}{M_s} 100 = \frac{260}{1200} 100 = 21\ \%$

$\theta_v = \frac{V_w}{V_t} 100$

$= \frac{260}{10 * 10 * 10} . 100 = 26\ \%$

$\rho_b = \frac{M_s}{V_t}$

$= \frac{1200\ gm}{1000\ cm^3} = 1.2\ gm/cm^3$

(10)

$$f = \left(1 - \frac{\rho_b}{\rho_s}\right) 100$$

$$= \left(1 - \frac{1.2}{2.65}\right) 100 = 54\ \%$$

$$\rho_s = \frac{M_s}{V_s}$$

$$V_s = \frac{M_s}{\rho_s} = \frac{1200\ gm}{2.65} = 452.8\ cm^3$$

$$V_a = V_t - (V_s + V_w)$$

$$= 1000 - (452 + 260) = 288\ cm^3$$ حجم الهواء

$$f_a = \frac{288}{1000} \times 100 = 28\ \%$$

Consistency :-

It is **a term used** to describe the resistance of soil at various moisture content to mechanical stress or manipulation . It is show the cohesion and adhesion forces , and determined the ease with which soil can be reshaped without cracking or breaking .

قوام التربة:-وهو مصطلح يستخدم لوصف مدى مقاومة التربة عند محتويات رطوبية مختلفة للجهود الميكانيكية او التلاعب باليد .وتوضح هذه الخاصية مدى قوى التماسك والتلاصق .ويمكن عن طريقها تقدير مدى سهولة إعادة تشكيل التربة دون تشقق او تكسر .

Shrinkage Limit :- *The moisture content below Which* the soil be shrink .

Lower plastic limit (plastic limit) :-It is defined as the water content at which soil being rolled into a thread 3 mm , in diameter .

Upper plastic limit (Liquid limit) :- It defined as the water content at which soil becomes semifluid . Or it is defined as the water content at which a trapezoidal groove of specified shape cut in moist soil held in a special cup is closed after 25 taps on a hard rubber plate.

The *sticky Limit :-* Is the water content at which soil no longer stick to a spatula .

The plastic Index : The moisture content Between liquid and plastic limits .

Procedure of plastic limit ;

1-knead 10 – 15 gm of stiff soil paste into a ball.

2- Roll out the soil on a glass plate or **Rubber** floor tile with the fingers until a thread 3 mm in diameter is formed .

3- Try to approach the two ends of **Thread** from each other carefully and gently to obtain a circle without any cracking .

4- Find the moisture content of the thread .

Procedure of liquid limit :-

1- Clean the liquid - limit device (**Casagrande,** device) and place about 30 ml of past in the cup , and smooth the surface level with the front of the cup to form a pat that is 1 cm .

2- Cut the groove by spatula and remove any

soil along the walls of groove more than 1 cm .The groove is 2mm wide of the bottom and slops out ward 60^{o} angle with horizontal .

3- Turn the crank at 2 revolution per second . Record the number of tap of the cup required to cause the soil to flow together.

4- Remix the soil in the cup , form a new groove , repeat step 3 and try to get 18- 32 taps (range 25 taps).

5- Take about 10 gm of soil past to find The moisture content.

Example:

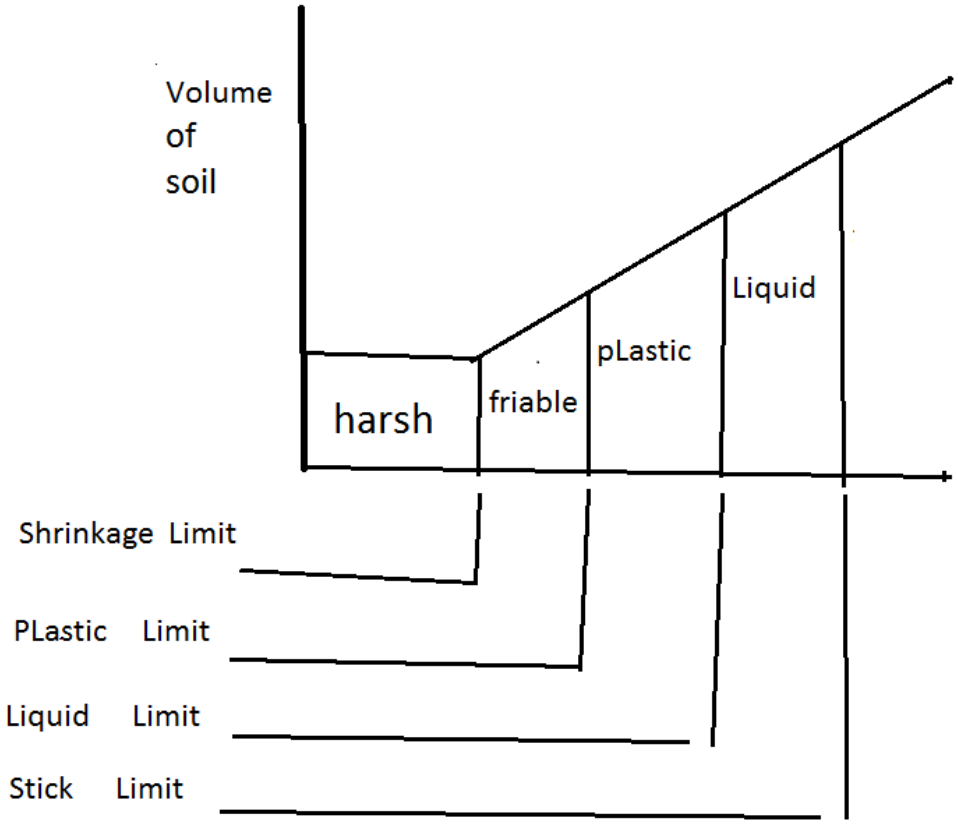
Calculate the moisture content at upper plastic limit , Lower plastic limit and plastic index .from the following data :-

	Wet weight	Dry weight (at $105^{o}C$ for 24 hr)
U.P.L	12 gm	8.66 gm
L.P.L	16 gm	12.99 gm

$$U.P.L = \frac{12-8.66}{8.66}100 = 38.5\%$$

$$L.P.L = \frac{16-12.99}{12.99}100 = 23.17\%$$

$$P.I = 38.5 - 23.17 = 15.33\%$$



Limits of soil consistency

Friable: Is the available water content for tillage process .

SOIL TEXTURE

Methods determination particle size distribution

Chemical distribution ;- BY using (H_2O_2 , HCL)

Physical distribution :- BY using (Calgon)

The methods is ;-

1- Hydrometer method .

2- Pipette method .

3- Centrifuge .

4- Elutriation .

5- Oden s automatic balance .

6- Sieves .

1- Hydrometer method :-

Procedure :-

1- Take about 40 gm oven dry soil sample (sieved two mm) in beaker 600 ml .

add 30mm of distillated water and 30 mL of H_2O_2 (hydrogen peroxide 6%) and shake the

2- Add 25 mL of 1N HCL to the soil sample to remove carbonates .

3- Wash the suspension by using distillated water in (washing bottle) .

4- Put the suspension in mixing cup of the stirrer ,add 50- 100mL of calgon (sodium hexa meta phosphate)then add distillated water to being the volume up 3/4 cup.

5- Mix the suspension for 3 minutes with electric mixer (stirrer).

6- Transfer the suspension to the sedimentation cylinder with help of washing bottle add distillated water to make the volume on one litter .

7- Insert the plunger up and down .

8- Insert the hydrometer (H.Y) gently .the first reading within 40 sec . the second reading within two hours .

9- Register the reading of suspension temperature .

Calculation:-

Correction Confident (C.C) =(Temp of suspension- 19.4) 0.3

Corrected hydrometer reading = reading of H.Y after 40 sec ±C.C.

$$(Clay + silt)\ \ percentage = \frac{corrected\ \ H.Y.reading}{Wt.\ of\ oven\ dry\ soil\ sample} 100$$

$$Clay\ \% = \frac{corrected\ \ reading\ \ of\ \ H.Y\ \ after\ \ 2\ hours}{W.t.of\ \ oven\ \ dry\ \ soil\ \ sample} 100$$

Silt % = (Clay % + Silt %) - Clay %

Sand = 100 – (Clay + Silt) %

Example;-

By using hydrometer method for mechanical analysis ,calculate the percentage of particle distribution (Clay , Silt , Sand) and naming soil texture .if you get ;-

Total weight of the soil sample 25 gm .

First reading of hydrometer 18

Second reading of hydrometer 8

Temperature of suspension 15°C

Calculation ;-

Correction Coefficient =(Tem of suspen-19.4)0.3

C.C = (15 - 19.4)0.3 = - 1.32

First Corrected reading = reading of H.Y ± C.C

= 18 – 1.32 = 16.68

$$(Clay + Silt)\% = \frac{16.68}{25} 100 = 66\%$$

Second corrected reading = 8 - 1.32 = 6.68

$$Clay\ \% = \frac{6.68}{25}100 = \ 26\%$$

Silt % = 66% - 26 % = 40%

Sand % = 100 - 66 % = 34 %

LOAM

Disadvantage of hydrometer .method ;-

1- Some times inserting the H.Y. in the suspension with no care gave unstable reading

2- Attacked of some particles with H.Y.

3- The H.Y. some time move to side of cylinder .

4- Turbulent the suspension through insert the H. Y.

2- Pipet method ;-

Procedure :-

1- Take about 20- 40 gm oven dry soil sample (sieved two mm) in beaker 600 ml .

add 30mm of distillated water and 30 mL of H_2O_2 (hydrogen peroxide 6%) and shake the suspention to remove organic matter .

2- Add 25 mL of 1N HCL to the soil sample to remove carbonates.

3- Wash the suspension by using distillated water in (washing bottle).

4- Put the suspension in mixing cup of the stirrer ,add 50- 100mL of calgon (sodium hexa meta phosphate)then add distillated water to being the volume up 3/4 cup.

5- Mix the suspension for 3 minutes with electric mixer (stirrer).

6 - Use 0.2 mm sieve to get a sand particles as soil suspension .Put the sand on glass watch and in an 105 °C for 24 hr .

7- Transfer to the sedimentation cylinder with help of washing bottle , add distillated water to make the volume on one litter .

8 – Fix about 10 cm depth on a cylinder using marker.

9 - Insert the plunger up and down .

10 – Holding the pipette along the center of the cylinder adjusted in the 10 cm depth .

11 – Get about 25 mL of suspension after 4 minute and 48 sec . put the suspension with a known weight can , this will represent the weight of (Clay + Silt) after drying by an oven at 105 °C for 24 hr .

12- After the end of 8 hr take the same volume of suspension by following the same step No; 11. The suspension after drying represent the weight of clay .

Calculation ;-

$$(Clay + Silt)\% = \left\{\frac{W_S}{W_t}\right\}\left\{\frac{V}{Y}\right\}100$$

Wt = total weight of the soil sample .
Ws = dry wt of the pipette sample.
Y = volume of the pipette .
V = Total volume of the suspension (1000cm^3).

$$Clay\ \% = \left\{\frac{W_S}{W_t}\right\}\left\{\frac{V}{Y}\right\}100$$

Silt % = (Clay + Silt) % - Clay %

Sand % = 100 - (Clay + Silt) %

By using pipette method for mechanical analysis , calculate the percentage of particle size distribution (clay, silt & sand) and naming soil texture . If you getting \

Total weight of the soil sample 25 gm

Dry wt of the pipette sample (clay+ silt = 0.5 gm) (clay = 0.3 gm)

Volume of the pipette = 25 ml

Total volume of the suspension = 1000 ml

Solution:-

$$(\text{Clay + Silt}) \% = \left(\frac{Ws}{Wt}\right)\left(\frac{V}{Y}\right)100$$

Wt = total weight of the soil sample .

Ws = dry wt of the pipette sample.

Y = volume of the pipette .

V = Total volume of the suspension .

$$(\text{Clay + Silt}) \% = \left(\frac{0.5}{25}\right)\left(\frac{1000}{25}\right)100$$

$$= 80 \%$$

$$\text{C lay} \% = \left(\frac{0.3}{25}\right)\left(\frac{1000}{25}\right)100$$

$$= 48 \%$$

Silt % = (Clay + Silt) % - (Clay)

= 80 – 48

= 32 %

Sand % = 100 – (Clay + Silt) %

= 100 – 80

= 20 %

SOIL TEXTURE IS CLAY

By using pipette method for mechanical analyses at mosul university soil gave the :-

0.5 gm weight of particle after 4.48 minute (first reading) .

0.3 gm weight of particle after 8 hours (second reading).

30 gm weight of soil sample was taken .

25 cm^3 volume of pipette .

Calculate each particle size percentage and named soil texture .

Solution :-

$$\text{Clay \&silt \%} = \frac{\text{Wt. of dry fraction}}{\text{Wt . of soil sample}} \times \frac{1000}{\text{pipette volume}} \times 100$$

$$\text{Clay \&silt \%} = \frac{0.5}{30} \times \frac{1000}{25} \times 100 = 66.66$$

$$\text{Clay \%} = \frac{\text{Wt. of dry fraction}}{\text{Wt . of soil sample}} \times \frac{1000}{\text{pipette volume}} \times 100$$

$$\text{Clay \%} = \frac{0.3}{30} \times \frac{1000}{25} \times 100 = 40\ \%$$

Silt % = (clay &silt)% - clay%

= 66.66 %- 40 % = 26.66 %

Sand % =100- 66.66 % = 33.34 %

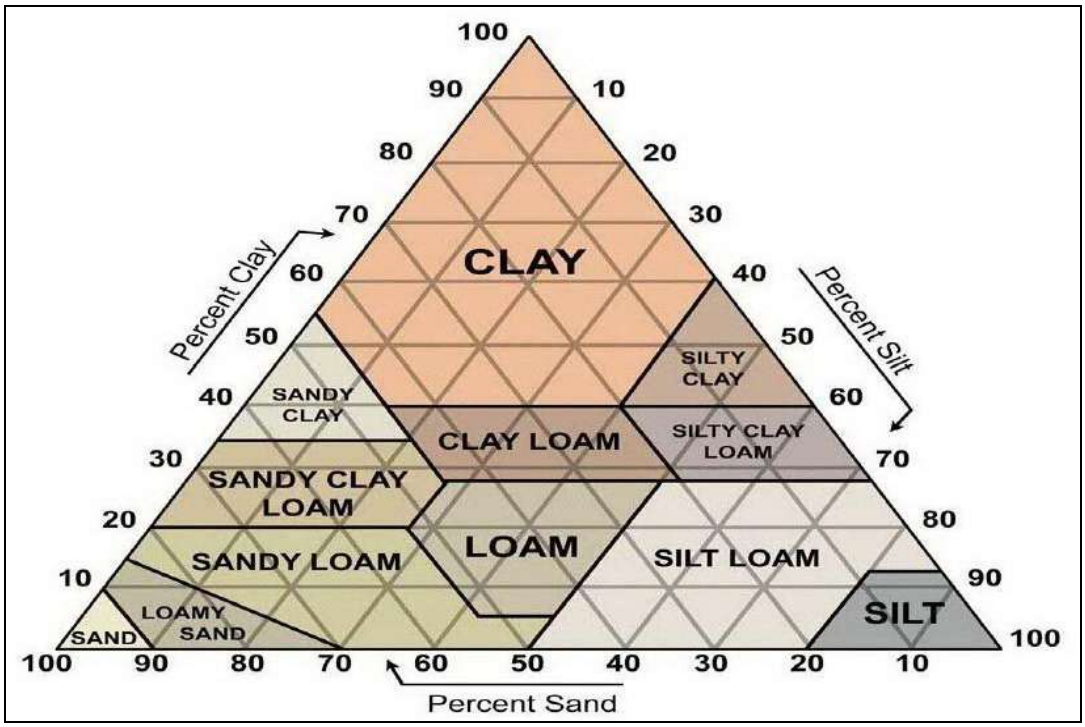
SOIL TEXTURE CLAY LOAM

Disadvantage of pipette method ;-

1- The pipette must be stable during the experiment .

2- Attacked of some particles with pipette.

3- Depth of the pipette must be fixed .



International Classification

التصنيف العالمي لحجوم دقائق التربة

Particle	Diameters\mm	Diameters micrometer
Sand	2 - 0.2	2000 - 200
Silt	0.2- 0.002	200 - 2
Clay	Less than 0.002	2

Bulk density

Bulk density :- Is the ratio between oven dry weight to the total volume of soil , it s, unit ($gm.cm^{-3}$) or ($Mg . m^{-3}$) .

Bulk density is not an invariant quantity for a given soil . It is varies with structural condition of the soil , particularly that related to packing . For this reason it is often used as a measure of soil structure .

الكثافة الظاهرية لاي تربة ليست ذات قيمة ثابتة . تتغير تبعا لظروف التربة التركيبية (نوع بناء التربة) ، وخصوصا التي ترتبط بالرص اثناء عملية اخذ عينة التربة . لهذا السبب غالبا ما تستخدم الكثافة الظاهرية للتعبير عن بناء التربة .

There are four methods to determinate bulk density :-

1- Core method .
2- Clod method .
3- Excavation method :-
   a- Sand – funnel apparatus
   b- Rubber - balloon apparatus .
4- Radiation methods :-
   a- Transmission apparatus .
   b- Scattering apparatus (Gamma radiation).

Core method :-

Procedure :-

1- Weigh the empty sampler core (metal cylinder).
2- Drive or press the core in to either a vertical or horizontal soil surface for enough to fill the core .
3- Carefully remove the core and its contents so as To preserve the nature structure and packing of The soil as nearly as possible.
4- Trim the soil extending beyond each end of the Core with straight knife or spatula .
5- Weigh the core with soil and place it in oven at 105° C for 24 hr .
6- Weigh the core with soil after drying .
7- Find the volume of soil (core volume).

Calculation ;-

$$\rho b = \frac{Dry\ \ Weight}{Volume\ \ of\ \ core}$$

Core Volume = $r^2 * \pi * h$

Benefit :-

This procedure not need big or complex equipment .

Disadvantage :-

1- In dry or hard soils hammering the core into the soil often shatters the soil sample and loosening may occur.
2- This method is unfavorable in gravelly and stony soil.

Example :-

The core weight 20 gm ,its length 5.4 cm and its diameter 5cm , core with soil sample is 155 gm ,core with dry soil sample (24 hr in oven & 105ºC) is 145 gm .calculate :-

1- Soil mass wetness.
2- Bulk density .
3- Porosity .
4- Soil volume wetness.

W1= weight of core
W2 = weight of core + wet soil .
W3 = weight of core + soil after drying .
V = Soil volume.(volume of the core)

$$\Theta m = \frac{W2 - W3}{W3 - W1} 100$$

$$\Theta m = \frac{155-145}{145-20} 100 = 8\%$$

$V = (2.5)^2 * 3.14 * 5.4 = 105.6\ cm^3$

$$\rho b = \frac{M s}{V t} = \frac{W3 - W1}{Vt}$$

$$\rho b = \frac{145-20}{105.6} = 1.18 \ gm/cm^3$$

$$f = \left(1 - \frac{\rho b}{\rho s} \right) 100$$

$$f = \left(1 - \frac{1.18}{2.65} \right) 100 = 55.47\ \%$$

$$\Theta v = \left\{ \theta m \frac{\rho_b}{\rho_w} \right\} 100$$

$$\theta v = \left\{ 0.08 \frac{1.18}{1} \right\} 100 = 9.44\%$$

Soil structure

Soil structure ;- It is define as the arrangement and regulation of soil particles in an unites called aggregates , and the stability of these aggregates under stress .

Types of soil structure :-

1- Granular and crumbs.

2- Angular blocky.

3- Sub - angular blocky .

4- Prismatic .

5- Platy.

There are two methods for measuring aggregate stability :-

1-Dry sieving which is indicated to the stability of Soil against wind erosion .

2- Wet sieving which is indicated to the stability of Soil against water erosion .

Procedure of dry sieving :-

1- Transfer the soil sample to the plastic sheet .

2- Gently , break the block into small pieces With hand or rubber hammer .

3- Remove the gravel and stones.

4- Pass the soil through sieve 8 mm to collect it in 5 mm.

5- Setup sieves series (5, 3, 2 ,1) as you can gat it , or use the available sieves and then arrange them according their sizes (from biggest on the top to smallest on the base).

6- Weigh (25 – 40 gm) of aggregates (passed through 8 mm sieve) and put it in the top of sieves , and sieving for 10 minutes .

7- Place each sieve in clean tray , dry at 105^{o} C For 24 hr . and weigh each fraction .

8- Find soil moisture to calculate the oven dry Weight .

Procedure of wet sieving :

Follow the same procedure of dry sieving , note that aggregates must be wetting under vacuum before sieving .

Calculation :-

From the following data calculate mean weight diameter (M.W.D) , then calculate aggregate stability (A. S .%) .

Sieve diameter / mm		Aggregate weight / gm	
X_1	8		
X_2	5	W_1	2
X_3	3	W_2	5
X_4	2.5	W_3	3
X_5	1.4	W_4	1
X_6	0.25	W_5	4

$$M.W.D = \sum_{i=1}^{n} X_i^- \, Wi$$

$$M.W.D = \left(\frac{X_1 + X_2}{2} \quad \frac{W_1}{W_t} \right) + \text{- - - - - +} \left(\frac{x_5 + X_6}{2} \quad \frac{W_5}{W_t} \right)$$

Mean weight diameter M.W.D

mean of sieve diameter X_i^-

weight of aggregate on sieve W_1

total of soil sample W_t

$$M.W.D = \left\{\frac{8+5}{2}\right\}\left\{\frac{2}{25}\right\} + \left\{\frac{5+3}{2}\right\}\left\{\frac{5}{25}\right\} + \left\{\frac{3+2.5}{2}\right\}\left\{\frac{3}{25}\right\} + \left\{\frac{2.5+1.4}{2}\right\}\left\{\frac{1}{25}\right\} + \left\{\frac{1.4+0.25}{2}\right\}\left\{\frac{4}{25}\right\}$$

$$M.W.D = (6.5)(0.08) + (4)(0.2) + (2.75)(0.12) + (1.95)(0.04) + (0.825)(0.16)$$

$$M.W.D = 0.25 + 0.8 + 0.33 + 0.078 + 0.132$$

$$M.W.D = 1.59\ mm$$

Aggregate stability %

Sieve diameter/ mm	**Aggre**gate weight/gm	**A.S %**
5	**2**	$\frac{\mathbf{2}}{\mathbf{25}}\mathbf{100} = \mathbf{8}\%$
3	**5**	$\frac{\mathbf{5}}{\mathbf{25}}\mathbf{100} = \mathbf{20}\%$
2.5	**3**	$\frac{\mathbf{3}}{\mathbf{25}}\mathbf{100} = \mathbf{12}\%$
1.4	**1**	$\frac{\mathbf{1}}{\mathbf{25}}\mathbf{100} = \mathbf{4}\%$
0.25	**4**	$\frac{\mathbf{4}}{\mathbf{25}}\mathbf{100} = \mathbf{16}\%$
		= 60%

Notice ;-

1- The aggregate mu**st be** wetting under vacuum and avoid direct wetting which causes aggregate crashing and trapping air .

2- The sand correction of sample must be done by adding calgon .

Example

Soil column is located horizontally , its length is 15cm , its cross section area is 40 cm^2 , the height of water is 12cm over the left end . The volume of water is collected from the right end is about 100 cm^3/ 2 hour . The reference level is 10 cm below the soil column . Calculate:-

Hydraulic head ΔH

Hydraulic gradient $i = \frac{\Delta H}{L}$

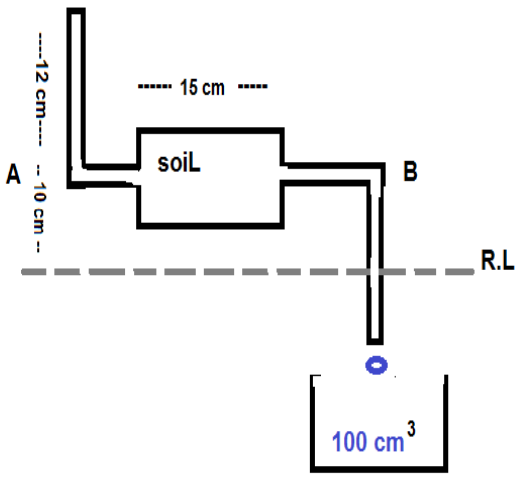
Discharge $Q = \frac{V}{T}$

Flux $q = \frac{v}{At}$

Saturated hydraulic conductivity K_S

$$Ks = \frac{V}{At} \quad \frac{L}{\Delta H} = q\frac{1}{i}$$

h_p	h_g	h_T
12	+10	+22
0	+10	+10



$\Delta H = hA - hB$

ΔH = 22 – 10 = 12cm----------1

$i = \frac{12}{15} = 0.8$ ----------*2-*

$$Q = \frac{V}{T} = \frac{100}{2}$$=50cm/hr----------3

$$q = \frac{V}{AT} = \frac{100}{40*2} = 1.25\ cm/hr$$----------*4*

$$Ks = \frac{V}{AT}\ \frac{L}{\Delta H} = q\ \frac{1}{i}$$

Ks =1.25 $\frac{1}{0.8}$

Ks=1.6 cm/hr----------5

Example

Soil column is located horizontally , its length is 15cm , its cross section area is 40 cm^2 , the height of water is 10cm over the left end . The volume of water is collected from the right end is about 6 cm^3/ 2min . The reference level is 8 cm below the soil column . Calculate:-

Hydraulic head ΔH

Hydraulic gradient $i = \frac{\Delta H}{L}$

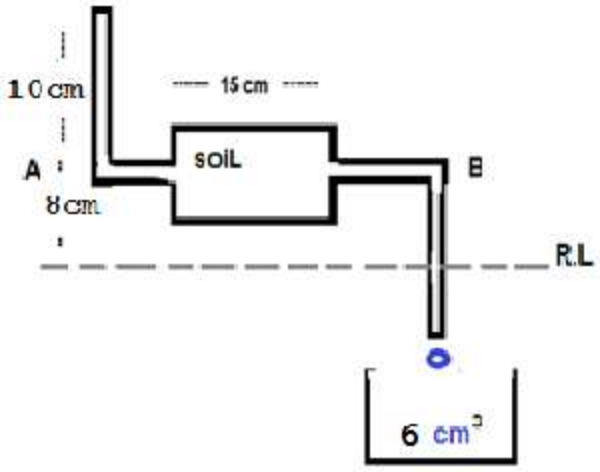
Discharge $Q = \frac{V}{T}$

Flux $q = \frac{v}{At}$

Saturated hydraulic conductivity K_S

$$Ks = \frac{V}{At} \quad \frac{L}{\Delta H} = q\frac{1}{i}$$

h_p	h_g	h_T
10	+8	+18
0	+8	+8



$\Delta H = h_A - h_B$

ΔH = 18 – 8 = 10 cm----------1

$i = \frac{10}{15} = 0.66$ ----------*2-*

$$Q = \frac{V}{T} = \frac{6}{2} = 3\ cm^3/min$$----------3

$$q = \frac{V}{AT} = \frac{6}{40*2} = 0.075\ ^{cm}/_{min}$$----------*4*

$$Ks = \frac{V}{AT}\ \frac{L}{\Delta H} = q\ \frac{1}{i}$$

$$Ks = 0.075\ \frac{1}{0.66}$$

Ks= 0.113 cm/min----------