LECTURE 38
17-APRIL-2013

GROUNDWATER HYDROLOGY

We had earlier told that we will discuss on subsurface water system later.
So in next few classes we will now deal with sub-surface flow system especially groundwater hydrology.

Ground water occurs in geologic zones in sub-surface that can bear and / or transmit water. Some of them are:

→ Gravels – coarse, medium, fine
→ Sand – " " "
→ Silt
→ Clay
→ Sandstone
→ Dolomite
→ Limestone
→ Peat
→ Loess
→ Shale, etc.

You have seen that groundwater is part of hydrologic cycle.
You have also heard about terms called aquifers.

Q: What is an aquifer?
It is the geological formation that can bear ~~to~~ and transmit water through its pores. In aquifers, all

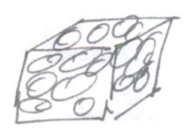
the pores will be filled with water. That is the porous medium is fully saturated.

→ Recall the terminologies — porosity, water content, residual water content, degree of saturation, etc.

<u>Specific surface</u> :→ It is the surface area per unit weight of the material.

Property of rock or soil

<u>Specific Retention</u> :-



You know porosity

$$\varepsilon = \frac{V_v}{V_t}$$

If V_w is the volume of water in the geologic formation, then out of this, how much amount will be retained in saturated condition against the force of gravity to the volume of geologic porous media is called specific retention

$$S_r = \frac{w_r}{V_t}$$

$w_r \rightarrow$ volume occupied by retained water
$V_t \rightarrow$ Total bulk volume of soil

<u>Specific Yield</u> :- Ratio of volume of water that will be drained by gravity to the volume of porous media.

$$S_y = \frac{w_y}{V_t} .$$

Now,

$$V_v = w_r + w_v$$

Also

$$\varepsilon = S_r + S_y$$

Values of specific yield → depends on grain size
distribution of pores
compaction of soil
time of drainage

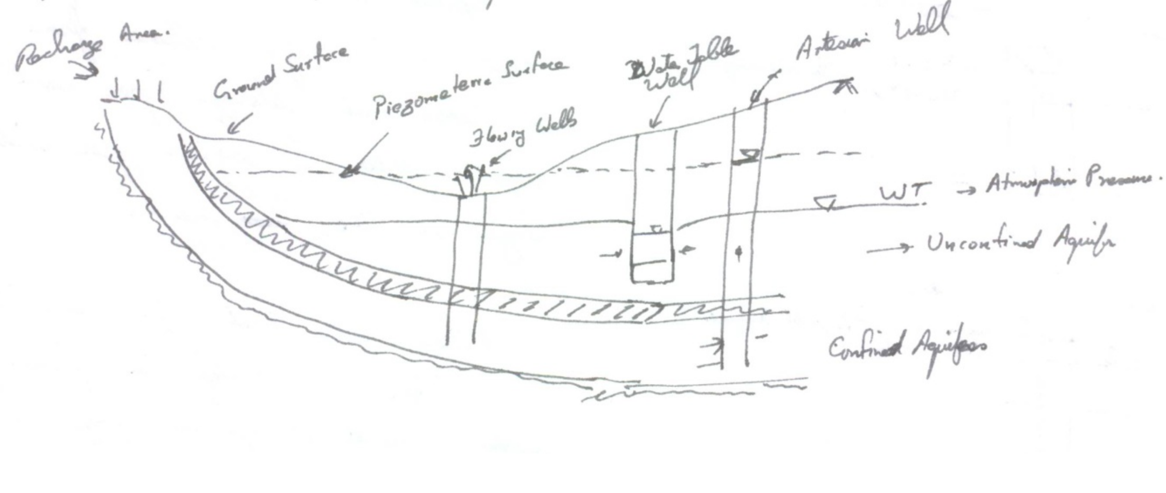
See specific yields :

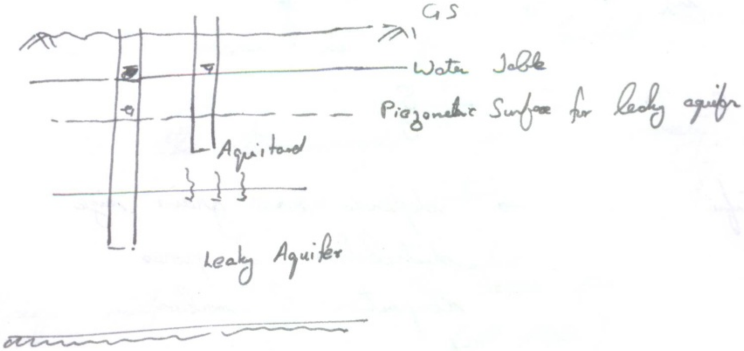
for gravel	→	23 - 25%
sand	→	28 - 23%
silt	→	8%
clay	→	3%
Limestone	→	14%
Sandstone	→	27% , etc.

Types of Aquifers

Unconfined aquifer → where water table varies in undulating form.

Confined aquifers : → the groundwater is confined under pressure greater than atmospheric.





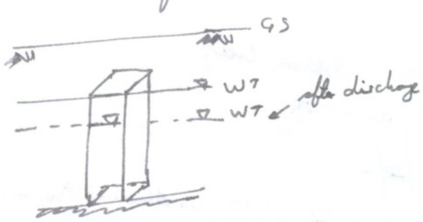
→ You have

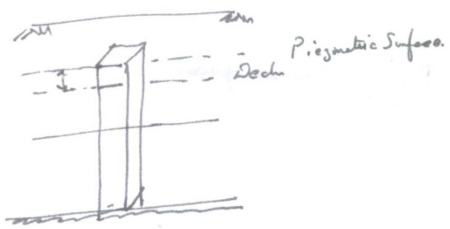
* Unconfined aquifer
* Confined aquifer
* Leaky aquifer

Storage Coefficient

There will be change in storage volume of the aquifer if water is discharged or recharged.

In unconfined aquifers:





A <u>storage coefficient</u> is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in the ~~con~~ hydraulic head.

Please note that in confined aquifers – changes in pressure produces small changes in storage volume.

For a vertical column of unit area in confined aquifer

→ let S be storage coefft.

S → the volume of water released from the confined aquifer when piezometric surface falls by unit distance.

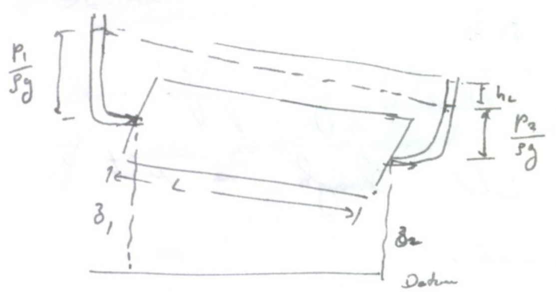
Usually $0.00005 < S < 0.005$ for confined aquifers.

Similarly for unconfined aquifers $S \rightarrow \frac{\text{Volume of water}}{\text{Unit Area} \times \text{Unit Head}}$.

The Groundwater Movement

Groundwater move according to hydraulic principles.

You know about Darcy's principles.



$$H_1 = \frac{p_1}{\rho g} + z_1$$

$$H_2 = \frac{p_2}{\rho g} + z_2$$

$$h_L = \left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right)$$

$$Q = -KA\frac{\Delta H}{\Delta L}$$

or $q = -K\dfrac{dh}{dL}$ Darcy principle.

(You have already done experiments on these).

Please note that Darcy law for groundwater movement is applicable only if R_n (Reynold's number) is less than 1. i.e. $R_n < 1.0$.

$$R_n = \frac{\rho V D}{\mu} = \frac{\rho q D}{\mu}$$

$\rho \rightarrow$ density of water
$V \rightarrow$ Darcy velocity $= q$
$\mu \rightarrow$ dynamic viscosity.

Intrinsic permeability: It is ~~φ~~ the permeability of rock or soil

~~k = K~~ such that $K = \frac{k \rho g}{\mu}$

$K \rightarrow$ hydraulic conductivity $[LT^{-1}]$
$k \rightarrow$ intrinsic permeability $[L^2]$

Transmissivity :→ $T = Kb$

where $b \rightarrow$ saturated thickness of aquifer.

Rate at which water is transmitted through a unit width under unit hydraulic gradient.

GW Flow Equations

Recall Porous media control volume:
RTT Applied on that gave

$$\frac{DB}{Dt} = \frac{d}{dt}\iiint_{CV} \rho \, dV + \int_{CS} \rho \vec{V}\cdot\hat{n} \, dA$$

i.e. $$\frac{d}{dt}\iiint_{CV} \rho \, dV = -\iint_{CS} \rho \vec{V}\cdot\hat{n} \, dA$$