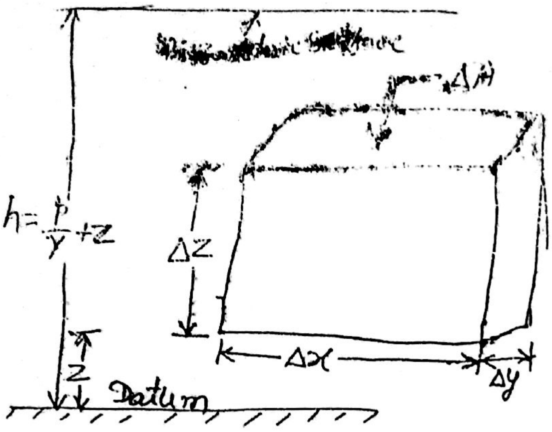
Hydrology

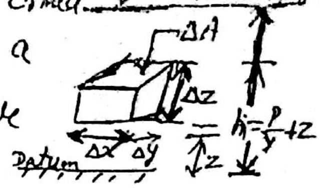
P.No.-401

Compressibility of aquifers :→

Pan Coefficient,
P.No. — 245
P.N. - 391 — Piezometric head
P No. — 389, Groundwater
Empirical formula of flood peaks - 3
" " " Evaporation
Analytical " " " " "
P.No. - 31 (Formula) Raingauge
Hudson's Formula (3·b)
Gumbel Formula ← Piezometric surface



Fig(a) ← Volume Element of a Compressible aquifer



Consider an elemental volume $\Delta V = (\Delta x \Delta y)\Delta Z = \Delta A \Delta Z$ of a Compressible aquifer

Assumptions :-

1) The elemental volume is constrained in lateral directions and undergoes change of length in the z-direction only i.e. ΔA is constant.

2) The pore water is compressible

3) The solid grains of the aquifer are incompressible but pore structure is compressible.

Compressibility of water, β is written as

$$\beta = -\frac{(d\Delta V_w)}{\Delta V_w} / dP \quad \text{——} (1)$$

where ΔV_w = Volume of water and P = Pressure

By ~~mass~~ ~~Conser~~ Conservation,

$\rho . \Delta V_w$ = Constant, where ρ = density of water

Thus, $\rho d(\Delta V_w) + \Delta V_w d\rho = 0$

Putting this relationship in eq. (1).

$$\beta = d\rho/(\rho dP) \quad \text{——} (2) \Rightarrow \beta = \frac{d\rho}{\rho dP}$$

$$\text{or, } d\rho = \rho \beta dP \quad \text{——} (3)$$

Compressibility of pores, α is expressed as

$$\alpha = -\frac{d(\Delta V)/\Delta V}{d\sigma_z} \quad \text{——} (4)$$

σ_z = intergranular pressure. Since $\Delta V = \Delta A \cdot \Delta Z$ with ΔA = Constant

$$\alpha = -\frac{d(\Delta z)/\Delta z}{d\sigma_z} \quad \text{—(5)}$$

Total overburden pressure, $w = P + \sigma_z$ = Constant

Thus, $dP = -d\sigma_z$ then Putting in eq. (5), we get

$$d(\Delta z) = \alpha(\Delta z)dP \quad \text{— (6)}$$

As the ~~V~~ ΔV_s = Constant

$$\Delta V_s = (1-n)\Delta A \cdot \Delta z = \text{Constant}$$

$$d(\Delta V_s) = (1-n)\,d(\Delta z) - \Delta z \cdot dn = 0$$

n = Porosity

From eq.(6)

$$dn = \alpha(1-n)dP \quad \text{— (7)}$$

Now, <u>mass of water</u> is

$$\Delta M = \rho n \Delta A \cdot \Delta z$$

$$\text{or, } d(\Delta M) = \Delta V\left[n\,d\rho + \rho\,dn + \rho n\frac{d(\Delta z)}{\Delta z}\right]$$

$$\text{i.e. } \frac{d(\Delta M)}{\rho \Delta V} = n\frac{d\rho}{\rho} + dn + n\frac{d(\Delta z)}{\Delta z}$$

~~i.e.~~ By (2), (7), (5), we have

$$\frac{d(\Delta M)}{\rho \Delta V} = n\beta dP + \alpha(1-n)dP + n\alpha dP = (n\beta+\alpha)dP$$

$$= \gamma(n\beta+\alpha)dh = S_s dh \quad \text{— (8)}$$

where, $S_s = \gamma(n\beta+\alpha)$ and h = Piezometeric head $= z + \frac{P}{\gamma}$

and $\gamma = \rho g$ = Unit weight of water

$S_s <<$ and equal to 1×10^{-4}m

By integrating eq. (8), we get

$$S = \gamma(n\beta+\alpha)B$$

S = Storage Coefficient or Storativity

S_s = Specific Storage

B = Thickness of Confined aquifer

For an unconfined aquifer

$$S = S_y + \gamma(\alpha + n\beta) B_s$$

B_s = Saturated thickness of the aquifer

The ratio of the water level change to pressure head change is called Barometric Efficiency (BE).

$$BE = -\left(\frac{n\beta}{\alpha + n\beta}\right)$$