PROPERTIES OF AQUIFER — BASIC EQUATIONS

(I) DIMENSION / UNITS

"L" = LENGTH UNITS (cm, mm, m etc)
"M" = MASS UNITS (gm, Kg)
"T" = TIME UNITS (SEC, MIN, DAYS)

II MATTER & ENERGY (BASIC PHYSICS)

1. $W = FD$ — WORK = (FORCE) (DISTANCE)

$$\left(\frac{ML^2}{T^2}\right) = \left(\frac{ML}{T^2}\right)(L)$$

2. $F = ma$ — f = force (ML/T^2)
 m = mass (M)
 a = acceleration (L/T^2)

3. $w = mg$ — w = weight (ML/T^2)
 g = acceleration due to gravity (M/T^2)
 m = mass (M)

4. $\rho = m/V$ — ρ = DENSITY (M/L^3)
 M = mass (M)
 V = VOLUME (L^3)

5. $\gamma = w/V$ — γ = SPECIFIC WEIGHT (M/L^2T^2)
 w = weight (ML/T^2)
 V = VOLUME (L^3)

6. By SUBSTITUTION $w = mg$, $m = V\rho$

$$\gamma = \frac{w}{V} = \frac{mg}{V} = \frac{V\rho g}{V} = \rho g \longrightarrow \boxed{\gamma = \rho g}$$

II. MATTER & ENERGY (CONT.)

7. $P = \frac{F}{A}$

P = PRESSURE (M/LT^2)
F = FORCE (ML/T^2)
A = X-sectional area (L^2)

III POROSITY OF EARTH MATERIALS

1. $n = \frac{100 V_v}{V_T}$

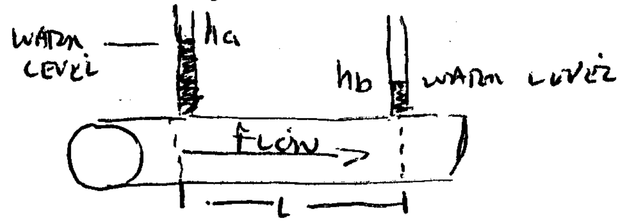
n = porosity (%)
V_v = VOLUME OF VOID SPACE (L^3)
V_T = VOLUME TOTAL (VOID + MATERIAL) (L^3)

2. SPECIFIC YIELD S_y = $\frac{\text{VOL. } H_2O \text{ GRAVITY DRAINED}}{\text{TOTAL VOLUME ROCK}}$

3. SPECIFIC RETENTION S_r = $\frac{\text{VOL. } H_2O \text{ RETAINED UNDER GRAVITY}}{\text{TOTAL VOLUME ROCK}}$

4. $n = S_y + S_r$

(5) DARCY'S LAW: CONSIDER A SAND-FILLED CONDUIT (LIKE AN AQUIFER)



ha = head pressure at pt. A

hb = head pressure at pt. B

$$Q = -KA\left(\frac{h_A - h_B}{L}\right) = -KA\left(\frac{dh}{dL}\right)$$

Q = DISCHARGE (L^3/T)

L = FLOW LENGTH (L) = dL

A = x-sectional area ⊥ TO FLOW

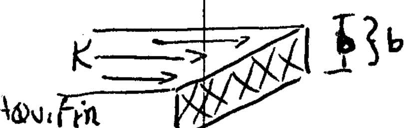
dh = head difference between a & b

K = HYDRAULIC CONDUCTIVITY = COEFFICIENT OF PERMEABILITY

(6) $$K = \frac{-Q}{A(dh/dL)} = \frac{-(L^3/T)}{(L^2)(L/L)} = L/T$$

THUS K ESSENTIALLY EQUALS THE "HORIZONTAL" PERMEABILITY OF AN AQUIFER

(7) TRANSMISSIVITY: ~~VOLUME~~ AMOUNT OF WATER TRANSMITTED HORIZONTALLY THROUGH THE UNIT WIDTH OF THE AQUIFER.



$$T = Kb$$

T = TRANSMISSIVITY (L^2/T)

b = SATURATED THICKNESS (L)

K = HYDRAULIC CONDUCTIVITY (L/T)

STORATIVITY

IN RESPONSE TO HEAD CHANGE IN AN AQUIFER, WATER WILL EITHER: 1) BE EXPELLED OR STORED

STORATIVITY – VOL. OF H_2O absorbed or expelled from STORAGE per UNIT SURFACE AREA PER UNIT HEAD CHANGE

$$\left(\frac{L^3/L^2}{L} = \frac{L^3}{L^2}\cdot\frac{1}{L} = L^3/L^3 = \text{DIMENSIONLESS RATIO}\right)$$

(FOR CONFINED AQUIFER)

(8) $S_s = \rho_w \cdot g \cdot (\alpha + n\beta)$

S_s = Specific STORAGE

ρ_w = DENSITY OF WATER (M/L^3)

g = ACCELERATION DUE TO GRAVITY (L/T^2)

α = compressibility of AQUIFER SKELETON $\left(\frac{1}{M/LT^2}\right)$

n = porosity (L^3/L^3)

β = compressibility of WATER $\left(\frac{1}{M/LT^2}\right)$

(FOR UNCONFINED AQUIFER) (GRAVITY DRAINAGE)

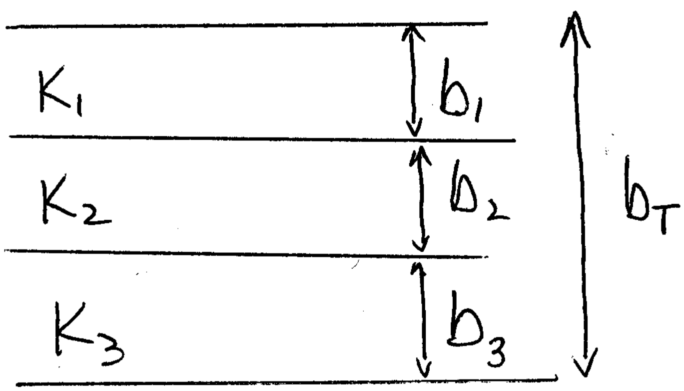
(9) $S = S_y$

S = STORATIVITY

S_y = SPECIFIC YIELD

(SEE EQUATION II-2)

Hydraulic Conductivity & Multilayer Aquifers



K_n = Hydraulic Conductivity of Layer 1, 2, 3

b_n = Thickness of layer 1, 2, 3

b_t = Total Aquifer Thickness

Average Horizontal Hydraulic Conductivity

$$K_{h(avg)} = \sum_{m=1}^{n} \frac{K_{hm} b_m}{b_t} = \frac{K_1 b_1 + K_2 b_2 + K_3 b_3}{b_t}$$

Average Vertical Hydraulic Conductivity

$$K_{v(avg)} = \frac{b_t}{\sum_{m=1}^{n} \frac{b_m}{K_{vm}}} = \frac{b_t}{\frac{b_1}{K_1} + \frac{b_2}{K_2} + \frac{b_3}{K_3}}$$

Gradient of Potentiometric Surface (Gradient Derived from Groundwater Elevations)

$$GRAD = \frac{dh}{dx}$$

Gradient = Slope of potentiometric surface

dh = change in elevation between 2 pts.

dx = distance between 2 pts.

INTRINSIC PERMEABILITY

$$K_i = Cd^2$$

K_i = intrinsic perm (L^2)
C = dimensionless constant
d^2 = mean pore diameter

$$K = K_i\left(\frac{\rho g}{\mu}\right)$$

K = Hydraulic conductivity (L/T)
ρ = density of fluid
g = gravity
μ = viscosity of fluid

PERMEAMETER EQUATIONS

① CONSTANT HEAD

$$K = \frac{VL}{Ath}$$

K = Hydraulic Conduc. (L/T)
V = Vol. of H_2O Discharge at time t (L^3)
L = LENGTH OF SAMPLE (L)
A = x-sectional area of SAMPLE (L^2)
h = hydraulic head (L)
t = time (T)

② FALLING HEAD

$$K = \frac{(d_t)^2 L}{(d_c)^2 t} \ln\left(\frac{h_0}{h}\right)$$

K = hydraulic conductivity (L/T)
L = LENGTH OF SAMPLE (L)
h_0 = initial head (L)
h = final head (L)
t = TIME from $H_0 \rightarrow H$ (T)
d_t = diameter falling head tube (L)
d_c = diameter of sample chamber (L)