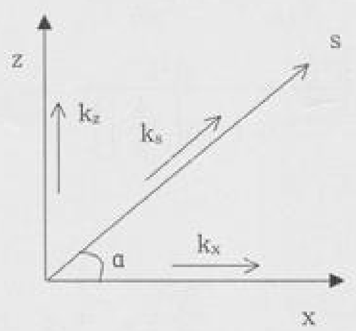
＊ Lecture note #10은 참고자료 (강의생략)

1. Anisotropic Soil conditions



＊ $v_x = -k_x i_x = -k_x \frac{\partial h}{\partial x}$

$v_z = -k_z \frac{\partial h}{\partial z}$

$v_s = -k_s \frac{\partial h}{\partial s}$

now, $\frac{\partial h}{\partial s} = \frac{\partial h}{\partial x}\frac{\partial x}{\partial s} + \frac{\partial h}{\partial z}\frac{\partial z}{\partial s}$

$\rightarrow \frac{v_s}{k_s} = \frac{v_x}{k_x}\cos a + \frac{v_z}{k_z}\sin a$

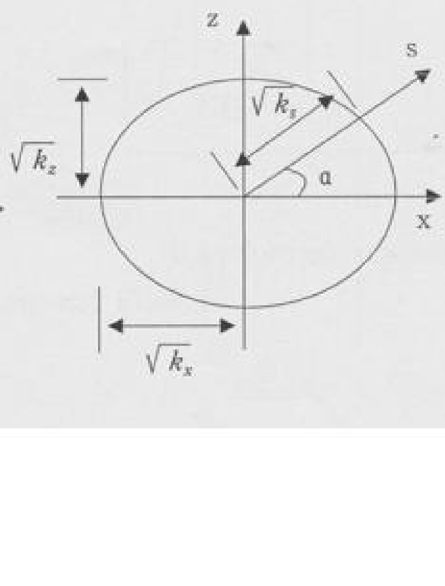
& $v_x = v_s \cos x$

$v_z = v_s \sin x$

thus, $\left(\frac{1}{k_s} = \frac{\cos^2 a}{k_x} + \frac{\sin^2 a}{k_z} \right)$

or $\frac{s^2}{k_s} = \frac{x^2}{k_x} + \frac{z^2}{k_z}$

"Directional variation of permeability" ⟶



* The equation of continuity for anisotropic case :

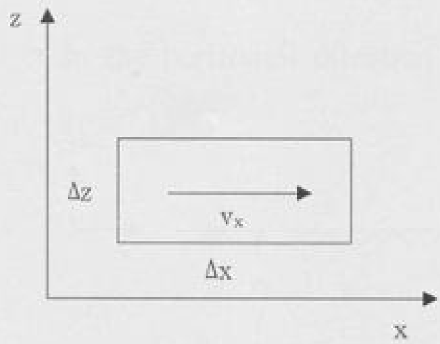
$$k_x \frac{\partial^2 h}{\partial x^2} + k_z \frac{\partial^2 h}{\partial z^2} = 0$$

$$\rightarrow \frac{\partial^2 h}{\left(\left(\frac{k_z}{k_x}\right)\partial x^2\right)} + \frac{\partial^2 h}{\partial z^2} = 0$$

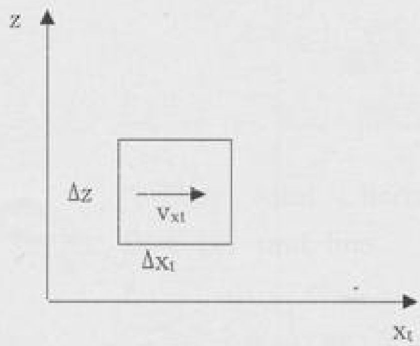
let, $x_t = x\sqrt{\frac{k_z}{k_x}}$

then, $\frac{\partial^2 h}{\partial x_t^2} + \frac{\partial^2 h}{\partial z^2} = 0$ [isotropic in x_t, z plane]

* Transformed scale



natural scale



transformed scale

(Elemental flow-net Field)

* The coefficient of permeability for the transformed section

$$k' = \sqrt{k_x k_z}$$

○ in x direction

$$v_x = v_{x_t} = -k'\frac{\partial h}{\partial x_t} = -k_x\frac{\partial h}{\partial x}$$

$$\rightarrow k'\frac{\partial h}{\sqrt{\frac{k_z}{k_x}}\,\partial x} = k'\sqrt{\frac{k_x}{k_z}}\frac{\partial h}{\partial x}$$

$$\rightarrow \ k'\sqrt{\frac{k_x}{k_z}} = k_x$$

$$\therefore k' = \sqrt{k_z k_x}$$

○ in z direction

$$q_z = -k'\frac{\partial h}{\partial z}\cdot \Delta x_t$$

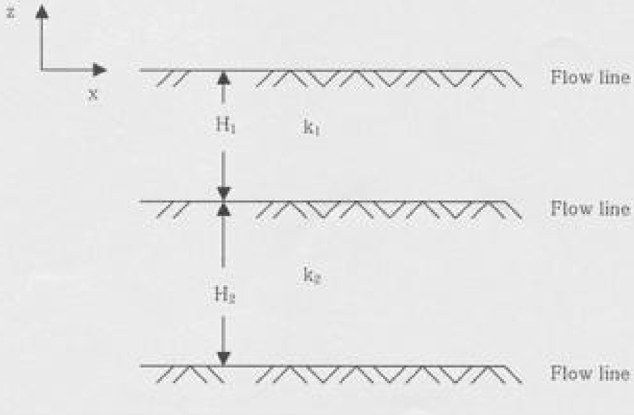
$$= -k'\frac{\partial h}{\partial z}\Delta x \cdot \sqrt{\frac{k_z}{k_x}}$$

$$= -\,k_z\frac{\partial h}{\partial z}\,\Delta x$$

$$\therefore k' = \sqrt{k_z k_x}$$

2. non-homogeneous soil condition

* In the horizontal direction



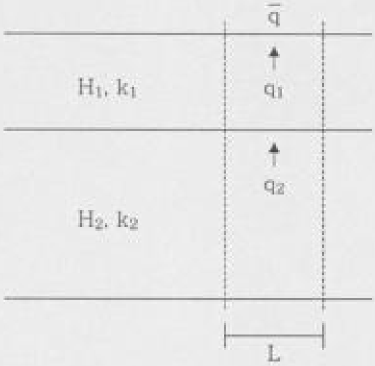
○ The total horizontal flow per unit line

$$\overline{q_x} = (H_1 + H_2)\,\overline{k_x}\,i_x$$

$$= (H_1 k_1 + H_2 k_2)\,i_x$$

$$\therefore \overline{k_x} = \frac{H_1 k_1 + H_2 k_2}{H_1 + H_2}$$

* In the vertical direction



$$v_z = \overline{k_z}\,\overline{i_z} = k_1 i_1 = k_2 i_2$$

$$\left(\because \overline{q} = q_1 = q_2 \quad \& \; L = constant \right)$$

From Eq. ①,

$$i_1 = \frac{\overline{k_z}}{k_1}\overline{i_z}, \quad i_2 = \frac{\overline{k_z}}{k_2}\overline{i_z}$$

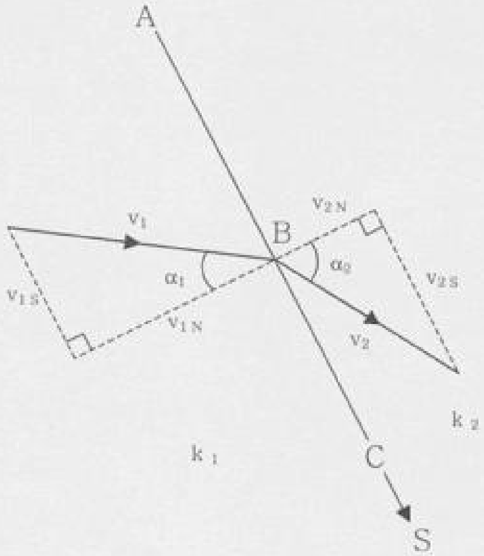
$$\overline{i_z}(H_1 + H_2) = i_1 H_1 + i_2 H_2 \quad (\rightarrow \text{total head loss} = \Sigma \Delta h_i)$$

$$= \overline{k_z}\,\overline{i_z}\left(\frac{H_1}{k_1} + \frac{H_2}{k_2}\right)$$

$$\therefore \overline{k_z} = (H_1 + H_2) \,/\, \left(\frac{H_1}{k_1} + \frac{H_2}{k_2}\right)$$

* $\overline{k_x} \,(\geq)\, \overline{k_z}$, $\quad (k_1 - k_2)^2 \geq 0$, OK

3. Transfer Condition



Let potential functions,

○ $\phi_1 = -k_1 h_1$, $\phi_2 = -k_2 h_2$

○ at pt. B, ($h_1 = h_2$)

$$\rightarrow \frac{\phi_1}{k_1} = \frac{\phi_1}{k_2} \quad ....②$$

Differentiating Eq. ② w.r.t. S,

$$\frac{1}{k_1}\frac{\partial \phi_1}{\partial S} = \frac{1}{k_2}\frac{\partial \phi_2}{\partial S} \quad ....③$$

Since, $v_x = -k_x i_x = -k_x \frac{\partial h}{\partial x}$ $\left[\ i.e.,\ v_s = -k_s \frac{\partial h}{\partial s}\ \right]$

Eq. ③ becomes,

$$\left(\frac{v_{1s}}{k_1} = \frac{v_{2s}}{k_2} \right)$$

& $v_{1n} = v_{2n}$ $[\because q_{1n} = q_{2n}\ ,\ A = const]$

$$\therefore \frac{1}{k_1}\frac{v_{1s}}{v_{1n}} = \frac{1}{k_2}\frac{v_{2s}}{v_{2n}}$$

$$\therefore \frac{\tan \alpha_1}{\tan \alpha_2} = \left(\frac{k_1}{k_2} \right)$$

* Flow nets :

$$\left(\frac{\triangle n}{\triangle s}\right)_1 = 1 \quad \rightarrow \quad \left(\frac{\triangle n}{\triangle s}\right)_2 = \frac{k_1}{k_2}$$