I. Heterogeneity

A. Homogeneous if conductivity is independent of position

B. Heterogeneous if conductivity is dependent on position

C. Freeze and Cherry (p. 30) discuss trending heterogeneity that occurs laterally in delta and alluvial fan deposits and vertically in soils

D. The directions in space corresponding to the maximum and minimum values of conductivity are termed the principal directions on anisotropy

E. Commonly layered horizontal rock are transversely isotropic, \( K_x = K_y \neq K_z \)

F. On a large scale, a heterogeneous layered system may be treated as anisotropy

1. consider horizontal flow in a vertically layered rock sequence

\[ Q_x = b Q_x = b K_x \Delta h / L \quad (1) \]

where \( b \) is the total thickness of the sequence and \( K_x \) is the effective horizontal conductivity.
3. $Q_x$ is also equal to the sum of the discharges from each of $n$ strata or

$$Q_x = \frac{\Delta h}{L} \sum_{i=1}^{n} b_i K_{xi} \tag{2}$$

so

$$bK_x \frac{\Delta h}{L} = \frac{\Delta h}{L} \sum_{i=1}^{n} b_i K_{xi} \tag{3}$$

$$K_x = \frac{1}{b} \sum_{i=1}^{n} b_i K_{xi} \tag{4}$$

4. Similarly, flow in the horizontal direction in a horizontally stratified sequence may be treated as a homogeneous, anisotropic material.

$$q_z = q_1 = q_2 = \ldots = q_n \tag{5}$$

$$q_z = \frac{K_1 \Delta h_1}{b_1} + \frac{K_2 \Delta h_2}{b_2} + \ldots + \frac{K_n \Delta h_n}{b_n} \tag{6}$$

But

$$q_z = K_z \frac{\Delta h}{b} \tag{7}$$

so

$$K_z = \frac{q_z b}{\Delta h} = \frac{q_z b}{\Delta h_1 + \Delta h_2 + \ldots + \Delta h_n} \tag{8}$$

therefore

$$K_z = \frac{q_z b}{K_1 + \frac{q_2 b_2}{K_2} + \ldots + \frac{q_n b_n}{K_n}} \tag{9}$$
or

$$K_Z = \frac{b}{n} \sum_{i=1}^{n} \frac{b_i}{K_i}$$

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