Darcy Columns

Saturday, February 29, 2020 8:16 AM

So what controls "groundwater" flow?

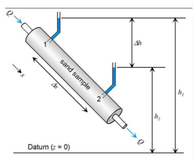
Solving in terms of discharge:

$$q = -K\frac{h_2 - h_1}{s}$$

Becomes:

$$Q = -K\frac{\Delta h}{\Delta s}A$$

This is Darcy's Law in the most popular form.



Components of Darcy's Law

$$Q = -K\frac{\Delta h}{\Delta s}A$$

Discharge [L^3/T] — Hydraulic Conductivity [L/T] — Hydraulic Gradient [-] — Area [L^2]

A. Based on the two Darcy's columns provided quantify the difference in groundwater discharge [cm^3/sec] between the Gravel column and the Silty Sand column.

Darcy's Law

$$Q = -k\frac{dh}{ds}A$$

For Gravel Column

$K = 10\ cm/sec$
$h_1 = 33\ cm$
$h_2 = 30\ cm$
$ds = 35\ cm$
$A = 225\ cm^2$

$$Q = -k\frac{h_2 - h_1}{ds}A$$

$$Q = -10\ cm/sec\ \frac{30cm - 33cm}{35cm}(225cm^2)$$

$$Q = 193\ cm^3/sec$$

For Sand Column

$K = 10^{-3}\ cm/sec$
$h_1 = 90\ cm$
$h_2 = 30\ cm$
$ds = 35\ cm$
$A = 225\ cm^2$

$$Q = -k\frac{h_2 - h_1}{ds}A$$

$$Q = 10^{-3}\ cm/sec\ \frac{30cm - 90cm}{35cm}(225cm^2)$$

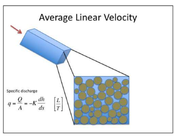
$$Q = 0.39\ cm^3/sec$$

B. Assuming the gravel column has an effective porosity of 0.30 and the silty sand column has an effective porosity of 0.25. Determine which column has a higher average linear velocity and by how much.

Here are a couple notes on average linear velocity that we should think about before solving this problem.

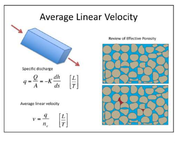
① The velocity of ground water flow is not the same as Specific discharge (q), even if they do have the same units

$$q = -k\frac{dh}{ds}\left[\frac{L}{T}\right]$$ ← This is not a true velocity.



Darcy's law takes a macroscopic approach, which assumes flow controls volume that ignores the grains. Which means that $q \neq V$.

② If the velocity of groundwater flow is then calculated based on flow in the void space we need to consider the volume of void space, which is porosity. Really we need connected void space so we need effective porosity.



Note: there are some zones within the void space that are not connected. See the red areas in the figure to the left. These zones are removed in our calculation of effective porosity. Really effective porosity is "connected porosity".

For Gravel Column

$$V_G = \frac{q}{n_e} \qquad V_G = \frac{0.86}{0.30} = 2.9\ cm/sec$$

For Sand Column

$$V_S = \frac{q}{n_e} \qquad V_S = \frac{0.0017}{0.25} = 0.0068\ cm/sec$$

Gravel has the higher velocity by 2.8932 cm/sec