Example of Verification of Darcy's Law Validity

EXAMPLE 3.1.3

The following additional information is given for the aquifer sample in Example 3.1.1. The sample has a median grain size of 0.037 cm and a porosity of 0.30. The test is conducted using pure water at 20°C. Determine the Darcy velocity, average interstitial velocity, and assess the validity of Darcy's law.

SOLUTION

Darcy velocity is computed using Equation (3.1.5):

$$v = -K\frac{dh}{dl} = -(23.54\ \text{m/day})(-0.326) = 7.67\ \text{m/day}$$

The average linear velocity is computed using Equation (3.1.6):

$$v_a = \frac{Q}{\alpha A} = \frac{v}{\alpha} = \frac{7.67\ \text{m/day}}{0.30} = 25.6\ \text{m/day}$$

In order to assess the validity of Darcy's law, we must determine the greatest velocity for which Darcy's law is valid using Equation (3.1.7), $N_R = \frac{\rho v D}{\mu}$, knowing Darcy's law is valid for $N_R < 1$. For water at 20°C, $\mu = 1.005 \times 10^{-3}\ \text{N/m}^2$ and $\rho = 998.2\ \text{kg/m}^3$, so that for $N_R = 1$,

$$v_{\max} = \frac{\mu}{\rho D} = \frac{1.005 \times 10^{-3}\ \text{kg/ms}}{(998.2\ \text{kg/m}^3)(0.00037\ \text{m})} = 0.00272\ \text{m/s} = 235\ \text{m/day}$$

Then Darcy's law will be valid for Darcy velocities equal to or less than 235 m/day for this sample. Thus, the answer we have found in Example 3.1.1 is valid since $v = 7.67\ \text{m/day} < 235\ \text{m/day}$. ■