A.O

4. Use the drag coefficient in Newton's equation to determine the particle settling velocity.

$$v_p = \sqrt{\frac{4g(sg-1)d}{3C_d}} = \sqrt{\frac{4(9.81\ \text{m/s}^2)(2.65-1)(0.5\times10^{-3}\ \text{m})}{3\times0.901}} = 0.109\ \text{m/s}$$

Because the initial assumed settling velocity (0.224 m/s) does not equal the settling velocity calculated by Newton's equation (0.109 m/s), a second iteration is necessary.

5. For the second iteration, assume a settling velocity value of 0.09 m/s, and calculate the Reynolds number. Use the Reynolds number to determine the drag coefficient, and use the drag coefficient in Newton's equation to find the settling velocity.

$$N_R = \frac{0.85(0.09\ \text{m/s})(0.5\times10^{-3}\ \text{m})}{(1.003\times10^{-6}\ \text{m}^2/\text{s})} = 38.1$$

$$C_d = \frac{24}{38.1} + \frac{3}{\sqrt{38.1}} + 0.34 = 1.456$$

$$v_p = \sqrt{\frac{4(9.81\ \text{m/s}^2)(2.65-1)(0.5\times10^{-3}\ \text{m})}{3\times1.456}} = 0.086\ \text{m/s}$$

Although the assumed settling velocity (0.09 m/s) and the calculated settling velocity (0.086 m/s) still do not agree, they are approaching closure. Successive iterations to calculate the actual settling velocity will be done as a homework problem.

Because the settling velocity used to compute the Reynolds number agrees with the settling velocity value from Newton's equation, the solution approach has been confirmed.

Discrete Particle Settling

In the design of sedimentation basins, the usual procedure is to select a particle with a terminal velocity v_c and to design the basin so that all particles that have a terminal velocity equal to or greater than v_c will be removed. The rate at which clarified water is produced is equal to

$$Q = Av_c \tag{5-25}$$

where Q = flowrate, L^3T^{-1} (m^3/s)
A = surface of the sedimentation basin, L^2 (m^2)
v_c = particle settling velocity, LT^{-1} (m/s)

Rearranging Eq. (5-25) yields

$$v_c = \frac{Q}{A} = \text{overflow rate, } LT^{-1}\ (\text{m}^3/\text{m}^2\cdot\text{d})$$