AREN 323 Soil Mechanics II Tutorial 1 Solutions

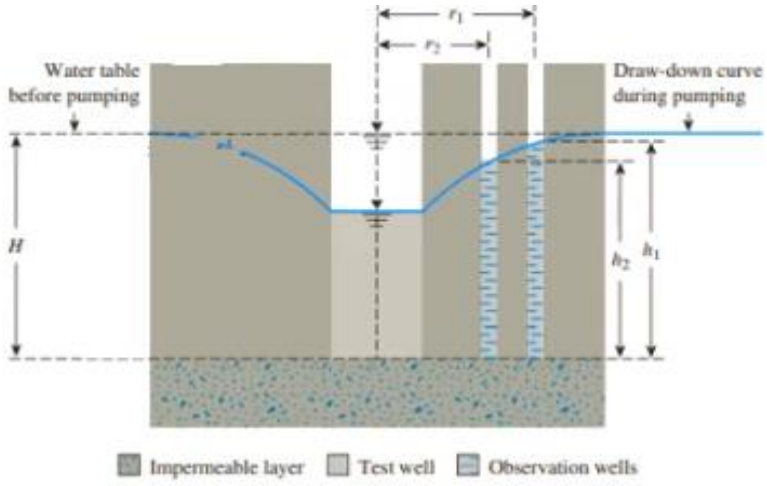
1. Given that:

Thickness of aquifer, H = 27 m

Flow rate, q = 69 litres/sec

Centre distance between the first observation well and the test well, r_1 = 95 m

Centre distance between the second observation well and the test well, r_2 = 35 m



Solution

a. Rate of flow in m^3/day.

q = 69 litres/sec

but 1mL = 1 cm^3

$$69\ \frac{L}{sec}\left(\frac{1000\ mL}{1\ L}\right)\left(\frac{1\ cm^3}{1\ mL}\right)\left(\frac{1\ m}{100\ cm}\right)\left(\frac{3600\ sec}{1\ hr}\right)\left(\frac{24\ hr}{1\ day}\right)$$

q = 5961.6 m^3/day

b. Find the hydraulic conductivity of the aquifer in m/day.

Hydraulic conductivity, k = $\frac{q\ ln\left(\frac{r_1}{r2}\right)}{\pi({h_1}^2-{h_2}^2)}$

$h_1 = (27 - 0.5)\ m$

$h_1 = 26.5\ m$

$h_2 = (27 - 1.1)\ m$

$h_2 = 25.9\ m$

k = $\frac{5961.6\ m^3/\ day\ ln\left(\frac{95\ m}{35\ m}\right)}{\pi((26.5\ m)^2-25.9\ m)^2)}$

k = 60.269 m/day

2. Given that:

q = 200 cm^3/sec

$h_1 = 6\ m$

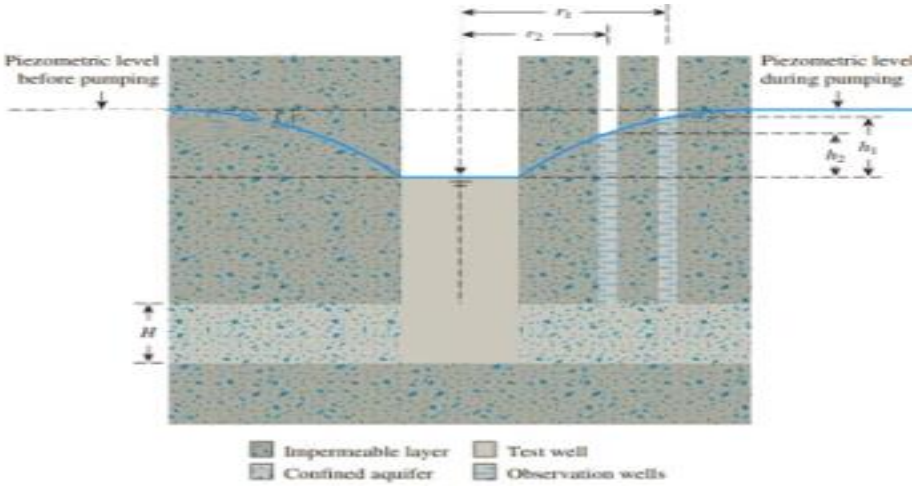
$h_2 = 4.5\ m$

$r_1 = 36\ m$

$r_2 = 18\ m$

H = 5 m

Find hydraulic conductivity in cm/day.



Hydraulic conductivity for confined aquifer,

$$k = \frac{q ln\left(\frac{r_1}{r_2}\right)}{2\pi H(h_1 - h_2)}$$

$$k = \frac{200\ cm^3/\sec \times ln\left(\frac{3600\ cm}{1800\ cm}\right)}{2\pi \times (500\ cm) \times (600\ cm - 450\ cm)}$$

$k = 2.942 \times 10^{-4}\ cm^3/sec$

3. Given that:

Q = 21.58 $in.^3$

L = 18 in.

A = 3.5 $in.^2$

t = 3 min

Find Hydraulic conductivity in in./sec.

Solution

Hydraulic conductivity for, k, for Constant Head Permeability Test,

$$k = \frac{QL}{Aht}$$

$$k = \frac{21.58\ in.^3 \times 18\ in.}{3.5\ in.^2 \times 28\ in.\ \times 3\ min}$$

k = 1.321 in/mi

$$k = 1.321\ \frac{in}{min}\left(\frac{1\ min}{60\ sec}\right)$$

$$\therefore k = 0.022\ in./sec$$

4. Given that:

L = 20 in.

A = 4 $in.^2$

a = 0.2 $in.^2$

$h_1 = 30\ in.$

$h_2 = 12\ in.$

$t_1 = 0$

$t_2 = 10\ mins$

Find hydraulic conductivity of the soil in in./min and head difference at t = 5min.

Solution

For Falling Head Permeability test,

$$k = 2.303\ \frac{aL}{A(t_2 - t_1)} log_{10}\left(\frac{h_1}{h_2}\right)$$

$$k = 2.303\ \frac{0.2\ in.^2 \times 20\ in.}{4\ in.^2(10\ mins - 0)} log_{10}\left(\frac{30\ in.}{12\ in.}\right)$$

k = 0.092 in./min

Head difference at t = 5min.

$$0.092\ in./min = 2.303\ \frac{0.2\ in.^2 \times 20\ in.}{4\ in.^2(5\ mins - 0)} log_{10}\left(\frac{30\ in.}{h_2}\right)$$

$$log_{10}\left(\frac{30\ in.}{h_2}\right) = \frac{0.092\ in./min}{0.4606\ in./min}$$

$$log_{10}\left(\frac{30\ in.}{h_2}\right) = 0.1997$$

$$\frac{30\ in.}{h_2} = 10^{0.1997}$$

$$h_2 = \frac{30\ in.}{10^{0.1997}}$$

$$h_2 = 18.94\ in.$$

5. Given that:

Thickness of aquifer, H = 20m

Transmissivity, T = 0.12 m^2/sec

Void ratio, e = 0.91

Hydraulic gradient, i = 0.0065

Solution

a. Find hydraulic conductivity.

T =k × H

0.12 m^2/sec = k × 20m

k = 6 × 10^{-3} m/sec

k = 0.006 m/sec.

b. Find seepage velocity.

Seepage velocity $v_s = \frac{flow\ velocty}{porosity} = \frac{v}{n}$

v = i × k

v = 0.0065 × 0.006 m/sec

v = 3.9×10^{-5} m/sec

but

n = $\frac{e}{1+e}$

n = $\frac{0.91}{1+0.91}$ = 0.4764

$v_s = \frac{3.9 \times 10^{-5}\ \mathrm{m/sec}}{0.4764}$

$v_s = 8.1864 \times 10^{-5}\ m/sec$

c. Time required for water to travel 1km through this aquifer.

Time required, t = $\frac{distance}{seepage\ velocity} = \frac{d}{v_s}$

t = $\frac{1000m}{8.1864 \times 10^{-5}\ m/sec}$

t = 12215381.61 s

t = 12215381.61 sec × $\left(\frac{1\ hr}{3600\ sec}\right) \times \left(\frac{1\ day}{24\ hr}\right)$

t = 141.26 days

6. Given that:

Rate of flow, q = 0.303 m^3/min

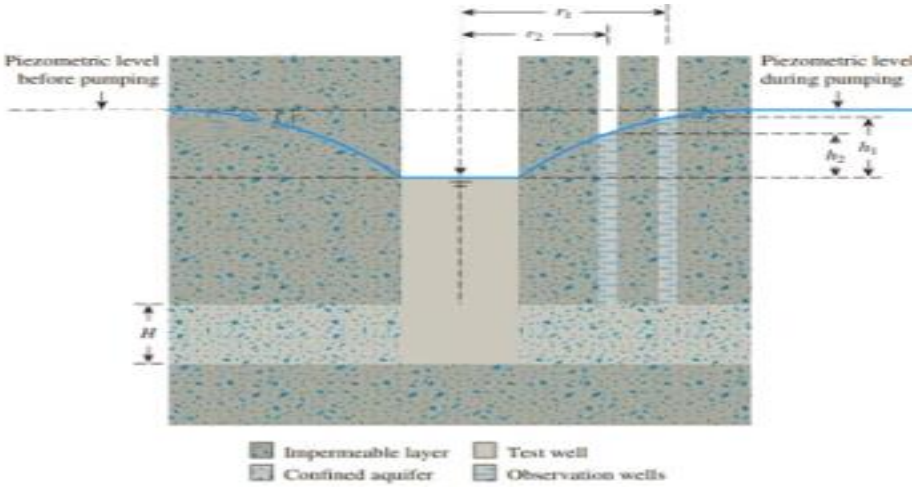
$h_1 = 2.44\ m$

$h_2 = 1.52\ m$

$r_1 = 18.3\ m$

$r_2 = 9.15\ m$

H = 3.05 m



Solution

Hydraulic conductivity for confined aquifer,

$$k = \frac{q ln\left(\frac{r_1}{r_2}\right)}{2\pi H(h_1 - h_2)}$$

$$k = \frac{0.303\ m^3/\min \times ln\left(\frac{18.3\ m}{9.15\ m}\right)}{2\pi \times (3.05\ m) \times (2.44\ m - 1.52\ m)}$$

k = 0.011912 m/min

$$k = 0.011912\ \frac{m}{min}\left(\frac{100\ cm}{1\ m}\right)\left(\frac{1\ min}{60\ sec}\right)$$

k = 0.019853 cm/sec

Tutorial Questions

1. A 300mm diameter test well penetrates 27 m below the static water table. After 24 hours of pumping at 69 litres/sec, the water level in an observation well at a distance of 95m form the test well is lowered 0.5 m and the other observation well at a distance of 35m m form the test well at a distance of 35 m from the test well, the drawdown is 1.1 m.

a. What is the rate of flow in cubic meters per day?

b. Compute the coefficient of permeability of the aquifer in meters per day.

2. A pumping test was performed in a well a confined aquifer to evaluate the coefficient of permeability of the soil in the aquifer. When equilibrium flow was reached, the following data were obtained:

a. Equilibrium discharge of water from the well is 200 cm^3/sec.

b. Water levels (h_1 and h_2) = 6 and 4.5m and at distances from the well (r_1 and r_2) of 36 and 18m, respectively.

c. Thickness of aquifer is 5m.

Find the hydraulic conductivity (cm/day).

3. Refer to the constant-head arrangement shown in Figure 7.5. For a test, the following are given.

L = 18 in.

A = area of the specimen = 3.5 $in.^2$

Constant-head difference, h = 28 in.

Water collected in 3 min = 21.58 $in.^3$. Calculate the hydraulic conductivity (in./sec).

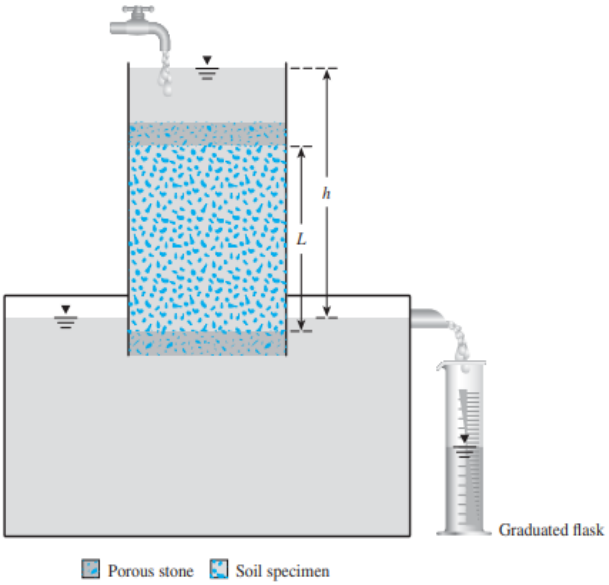


Figure 7.5 Constant-head permeability test

4. For a falling-head permeability test, the following are given:

Length of the soil specimen = 20 in.

Area of the soil specimen = 4 in.2

Area of the standpipe = 0.2 in.2

Head difference at time t = 0 is 30 in.

Head difference at time t = 10 min is 12 in.

Determine the hydraulic conductivity of the soil (in./min).

What was the head difference at time t = 5 min?

5. A certain 20 m thick sandy aquifer has a transmissivity of 0.12 m^2/sec and a void ratio of 0.91. Ground water is flowing through this aquifer with a hydraulic gradient of 0.0065.

a. Compute the hydraulic conductivity of the sand aquifer.

b. Compute the seepage velocity.

c. How much time would be required for water to travel 1km through this aquifer?

6. A pumping test from confined aquifer yielded the following results:

q = 0.303 m^3/ min, h1 = 2.44 m, h2 = 1.52 m, r1 = 18.3 m, r2 = 9.15 m and H = 3.05 m. Refer to the figure and determine the magnitude of k of the permeable layer in cm/sec.