Chapter 7

7.1 $$k = \frac{QL}{Aht} = \frac{(21.58)(18)}{(3.5)(28)(180\,\text{sec})} = \mathbf{0.022\,in./sec}$$

7.2 a. $$k = \frac{QL}{Aht} = \frac{(620\,\text{cm}^2)(30\,\text{cm})}{(175\,\text{cm}^2)(50\,\text{cm})(180\,\text{sec})} = \mathbf{1.18 \times 10^{-2}\ cm/sec}$$

b. $$v_s = v\left(\frac{1+e}{e}\right); \quad v = ki$$

$$v_s = ki\left(\frac{1+e}{e}\right) = (0.0118)\left(\frac{50\,\text{cm}}{30\,\text{cm}}\right)\left(\frac{1+0.58}{0.58}\right) = \mathbf{0.0536\ cm/sec}$$

7.3 $$k = \frac{QL}{Aht}; \quad 0.006 = \frac{(450)(12)}{(15)(h)(60\times 60)}$$

h = **16.67 in.**

$$v = ki = (0.006)\left(\frac{16.67}{12}\right) = \mathbf{0.0083\,in./sec}$$

7.4 a. $$k = 2.303\left(\frac{aL}{At}\right)\log_{10}\left(\frac{h_1}{h_2}\right) = (2.303)\left[\frac{(0.2)(20)}{(4)(10)}\right]\log_{10}\left(\frac{30}{12}\right)$$

$$= \mathbf{9.16 \times 10^{-2}\ in./min}$$

b. $$k = 2.303\left(\frac{aL}{At}\right)\log_{10}\left(\frac{h_1}{h_2}\right)$$

$$0.0916 = (2.303)\left[\frac{(0.2)(20)}{(4)(5)}\right]\log_{10}\left(\frac{30}{h_2}\right) = 0.4606\log\left(\frac{30}{h_2}\right)$$

$$0.1989 = \log_{10}\left(\frac{30}{h_2}\right); \quad 1.58 = \left(\frac{30}{h_2}\right)$$

h_2 = **18.99 in.**

7.5 $$k = 2.303\left(\frac{aL}{At}\right)\log_{10}\left(\frac{h_1}{h_2}\right); \quad 0.175 = (2.303)\left(\frac{a \times 38}{6.5 \times 8}\right)\log_{10}\left(\frac{650}{300}\right)$$

a = **0.31 cm^2**

7.6 a. $$k = 2.303\left(\frac{aL}{At}\right)\log_{10}\left(\frac{h_1}{h_2}\right)$$

$$= (2.303)\left(\frac{1.05 \times 70}{20 \times 8}\right)\log_{10}\left(\frac{800}{500}\right) = 0.216 \text{ cm/min} = 0.0036 \text{ cm/sec}$$

$$\overline{K} = \frac{k\eta}{\gamma_w} = \frac{(0.0036 \text{ cm/sec})(1.005 \times 10^{-3} \text{ N} \cdot \text{s/m}^2)}{9.789 \times 10^3 \text{ N/m}^3} = \mathbf{3.7 \times 10^{-10}\ m^2}$$

b. $$k = 2.303\left(\frac{aL}{At}\right)\log_{10}\left(\frac{h_1}{h_2}\right)$$

$$0.216 \text{ cm/min} = (2.303)\left(\frac{1.05 \times 70}{20 \times 6}\right)\log_{10}\left(\frac{800}{h_2}\right)$$

h_2 = **562.3 mm**

7.7 $q = kiA$

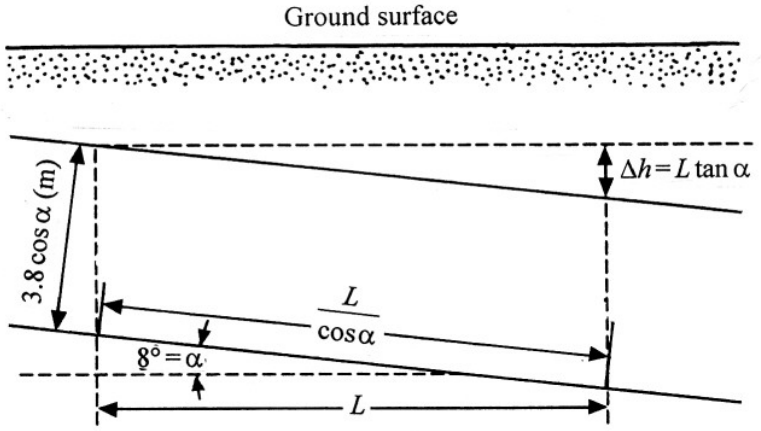
$$i = \frac{160 - 145}{180} = 0.0833$$

$$k = 2.8 \text{ m/day} = \frac{2.8}{(24)(60)} = 0.00194 \text{ m/min}$$

$A = 1.6 \times 800 = 1280 \text{ m}^2$

q = (0.00194)(0.0833)(1280) = **0.207 m^3/min**

7.8



From the figure: $i = \dfrac{\text{head loss}}{\text{length}} = \dfrac{L\tan\alpha}{\left(\dfrac{L}{\cos\alpha}\right)} = \sin\alpha$

$q = k\,i\,A = (k)(\sin\alpha)(3.8\cos\alpha)(1)$

$k = 5.2\times10^{-4}$ cm/sec = 5.2×10^{-6} m/sec

$$q = (5.2\times10^{-6})(\sin 8°)(3.8\cos 8°)\underbrace{(3600)}_{\text{to change to m/hr}} = 0.0098\ \text{m}^3/\text{hr/m}$$

$\approx$ **9.8×10^{-3} m^3/hr/m**

7.9 $$i = \frac{h}{\left(\dfrac{L}{\cos\alpha}\right)}$$

$$q = kiA = k\left(\frac{h\cos\alpha}{L}\right)(H_1\cos\alpha\times1) = \left(\frac{0.05}{\underbrace{10^2}_{\text{m/sec}}}\right)\left(\frac{3.1\cos 5}{60}\right)(2.8\cos 5)$$

= (0.005)(0.0515)(2.79) = **7.18×10^{-5} m^3/sec/m**

7.10 Eq. (7.31): $\dfrac{k_1}{k_2} = \dfrac{\dfrac{e_1^3}{1+e_1}}{\dfrac{e_2^3}{1+e_2}}$, or $\dfrac{0.022}{k_2} = \dfrac{\left(\dfrac{0.5^3}{1+0.5}\right)}{\left(\dfrac{0.7^3}{1+0.7}\right)} = \dfrac{0.0833}{0.2018}$

k_2 = **0.053 cm/sec**

7.11 $n_1 = 0.31;\ e_1 = \dfrac{n_1}{1-n_1} = \dfrac{0.31}{1-0.31} = 0.449$

$n_2 = 0.4;\ e_2 = \dfrac{0.4}{1-0.4} = 0.667$

Eq. (7.31): $k_2 = k_1\left(\dfrac{e_2^3}{1+e_2}\right)\left(\dfrac{1+e_1}{e_1^3}\right) = k_1\left(\dfrac{1+e_1}{1+e_2}\right)\left(\dfrac{e_2}{e_1}\right)^3 = (0.2)\left(\dfrac{1.449}{1.557}\right)\left(\dfrac{0.667}{0.449}\right)^3$

$= \mathbf{0.57\ ft/min}$

7.12 $\rho_{d(\text{field})} = R\rho_{d(\max)} = (0.8)(1800) = 1440\ \text{kg/m}^3$

$e = \dfrac{G_s\rho_w}{\rho_{d(\max)}} - 1 = \dfrac{(2.66)(1000)}{1440} - 1 = 0.847$

Eq. (7.34): $k\ (\text{cm/sec}) = 35\left(\dfrac{e^3}{1+e}\right)(C_u^{0.6})(D_{10}\ \text{mm})^{2.32}$

$= 35\left(\dfrac{0.847^3}{1+0.847}\right)(2.2^{0.6})(0.15)^{2.32} = \mathbf{0.227\ cm/sec}$

7.13 $e = e_{\max} - (e_{\max} - e_{\min})D_r = 0.7 - (0.7 - 0.46)(0.6) = 0.556$

Eq. (7.32): $k\ (\text{cm/sec}) = 2.4622\left[D_{10}^2\dfrac{e^3}{1+e}\right]^{0.7825}$

$= (2.4622)\left[(0.2)^2\left(\dfrac{0.556^3}{1+0.556}\right)\right]^{0.7825} = \mathbf{0.354\ cm/sec}$

7.14

Sieve no.	Opening (cm)	Percent passing	Fraction between two consecutive sieves (%)
30	0.06	100	
			{– – – – 20
40	0.0425	80	
			{– – – – 12
60	0.02	68	
			{– – – – 40
100	0.015	28	
			{– – – – 28
200	0.0075	0	

For fraction between sieve Nos. 30 and 40:

$$\frac{f_i}{D_{li}^{0.404} \times D_{si}^{0.595}} = \frac{20}{0.06^{0.404} \times 0.0425^{0.595}} = 407.98$$

For fraction between sieve Nos. 40 and 60:

$$\frac{f_i}{D_{li}^{0.404} \times D_{si}^{0.595}} = \frac{12}{0.0425^{0.404} \times 0.02^{0.595}} = 441.03$$

For fraction between sieve Nos. 60 and 100:

$$\frac{f_i}{D_{li}^{0.404} \times D_{si}^{0.595}} = \frac{40}{0.02^{0.404} \times 0.015^{0.595}} = 2362.8$$

For fraction between sieve Nos. 100 and 200:

$$\frac{f_i}{D_{li}^{0.404} \times D_{si}^{0.595}} = \frac{28}{0.015^{0.404} \times 0.0075^{0.595}} = 2812.2$$

$$\sum \frac{\sum 100\%}{D_{li}^{0.404} \times D_{si}^{0.595}} = \frac{100}{404.98 + 441.03 + 2362.8 + 2812.2} = 0.0166$$

$$k = (1.99 \times 10^4)(0.0166)^2 \left(\frac{1}{6.5}\right)^2 \left(\frac{0.5^3}{1+0.5}\right) = \mathbf{0.0108\ cm/sec}$$

7.15 $$\frac{k_1}{k_2} = \left(\frac{e_1^n}{1+e_1}\right)\left(\frac{1+e_2}{e_2^n}\right) = \left(\frac{1+e_2}{1+e_1}\right)\left(\frac{e_1}{e_2}\right)^n$$

$$\frac{1.2 \times 10^{-6}}{3.6 \times 10^{-6}} = \left(\frac{2.4}{1.8}\right)\left(\frac{0.8}{1.4}\right)^n ;\ 0.25 = 0.571^n$$

$$n = \frac{\log 0.25}{\log 0.571} = \frac{-0.602}{-0.243} = 2.477$$

$$k_1 = C\left(\frac{e_1^n}{1+e_1}\right); \quad C = \frac{(1.2 \times 10^{-6})(1+0.8)}{0.8^{2.477}} = 3.754 \times 10^{-6}\ \text{cm/sec}$$

$$k_3 = \left(\frac{0.9^{2.477}}{1.9}\right)(3.754 \times 10^{-6}) = \mathbf{1.52 \times 10^{-6}\ cm/sec}$$

7.16 $$\log k = \log k_0 - \frac{e_0 - e}{0.5 e_0} = \log(0.91 \times 10^{-6}) - \left(\frac{2.1 - 1.1}{0.5 \times 2.1}\right) = \mathbf{0.1 \times 10^{-6}\ cm/sec}$$

7.17 $$k_{H(\text{eq})} = \frac{1}{H}(k_1H_1 + k_2H_2 + ...)$$

$$k_{H(\text{eq})} = \frac{1}{7}[(10^{-5})(1.5) + (300\times10^{-5})(2.5) + (3.5\times10^{-5})(3)]$$

$$= \frac{10^{-5}}{7}(1.5 + 750 + 10.5) = 108.86\times10^{-5} \text{ cm/sec}$$

$$k_{V(\text{eq})} = \frac{H}{\frac{H_1}{k_1} + \frac{H_2}{k_2} + ...} = \frac{7}{\frac{1.5}{10^{-5}} + \frac{2.5}{300\times10^{-5}} + \frac{3}{3.5\times10^{-5}}}$$

$$= 2.96\times10^{-5} \text{ cm/sec}$$

$$\frac{k_{H(\text{eq})}}{k_{V(\text{eq})}} = \frac{108.86\times10^{-5}}{2.96\times10^{-5}} = \mathbf{36.8}$$

7.18 $$k_{V(\text{eq})} = \frac{H}{\frac{H_1}{k_1} + \frac{H_2}{k_2} + \frac{H_3}{k_3} + \frac{H_4}{k_4}} = \frac{4}{\frac{1.5}{20\times10^{-4}} + \frac{1}{2\times10^{-4}} + \frac{1.5}{10^{-4}} + \frac{1}{3\times10^{-4}}}$$

$$= 2.408\times10^{-4} \text{ cm/sec}$$

$$k_{V(\text{eq})} = \frac{1}{H}(H_1k_1 + H_2k_2 + H_3k_3 + H_4k_4)$$

$$= \frac{1}{5}[(1.5)(20\times10^{-4}) + (1)(2\times10^{-4}) + (1.5)(10^{-4}) + (1)(10^{-4})]$$

$$= 6.9\times10^{-4} \text{ cm/sec}$$

$$\frac{k_{H(\text{eq})}}{k_{V(\text{eq})}} = \frac{6.9\times10^{-4}}{2.408\times10^{-4}} = \mathbf{2.865}$$