Chapter 8

8.1 Eq. (8.14): $h_2 = \dfrac{h_1 k_1}{H_1\left(\dfrac{k_1}{H_1} + \dfrac{k_2}{H_2}\right)}$

$$8\,\text{cm} = \frac{(20\,\text{cm})(0.004\,\text{cm/sec})}{(10\,\text{cm})\left(\dfrac{0.004\,\text{cm/sec}}{10\,\text{cm}} + \dfrac{k_2\ \text{cm/sec}}{15\,\text{cm}}\right)}$$

k_2 = **0.009 cm/sec**

8.2 The flow net is shown. $K = 4 \times 10^{-4}$ cm/sec.

$H = H_1 - H_2$

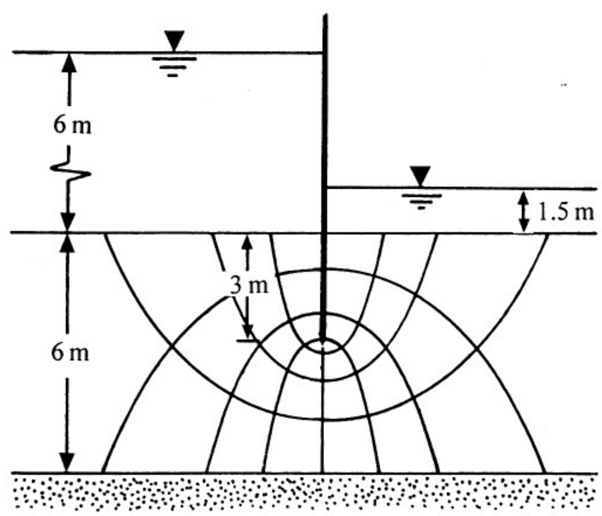
$= 6.0 - 1.5 = 4.5$ m.

So

$$q = \left(\frac{4\times10^{-4}}{10^2}\right)\left(\frac{4.5\times4}{8}\right)$$

$= 9\times10^{-6}\ \text{m}^3\text{/m/sec}$

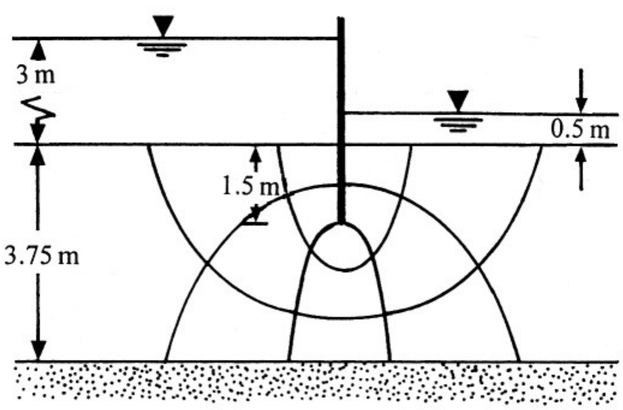
$= \mathbf{77.76\times10^{-6}\ m^3/m/day}$



8.3 The flow net is shown.

$N_f = 3$; $N_d = 5$

$$q = kH\left(\frac{N_f}{N_d}\right)$$



$$q = \left(\frac{4\times10^{-4}}{10^2}\ \text{m/sec}\right)(3-0.5)\left(\frac{3}{5}\right) = 6\times10^{-6}\ \text{m}^3\text{/m/sec} = \mathbf{0.518\ m^3/m/day}$$

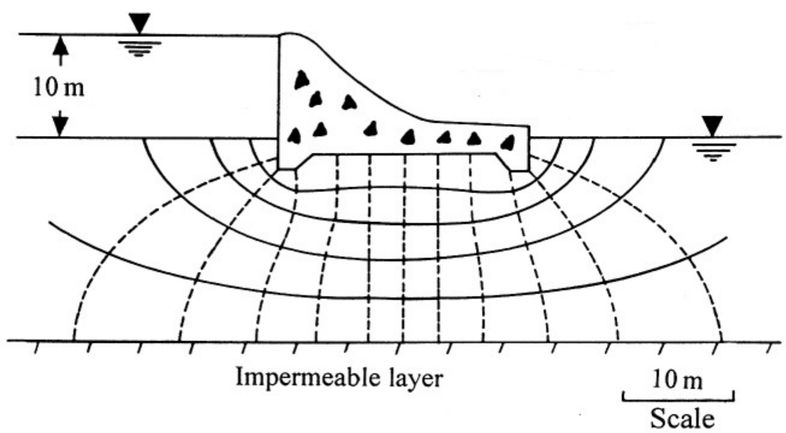
8.4 Based on the notations in Figure 8.10:

$H = (4 - 1.5)\text{m} = 2.5$ m; $S = D = 3.6$ m; $T' = D_1 = 6$ m; $S/T' = 3.6/6 = 0.6$

From the figure, $\dfrac{q}{kH} \approx 0.44$.

$$q = (0.44)(2.5)\left(\frac{4\times10^{-4}}{10^2}\times60\times60\times24\ \text{m/day}\right) = \mathbf{0.38\ m^3/m/day}$$

8.5 The flow net is shown.



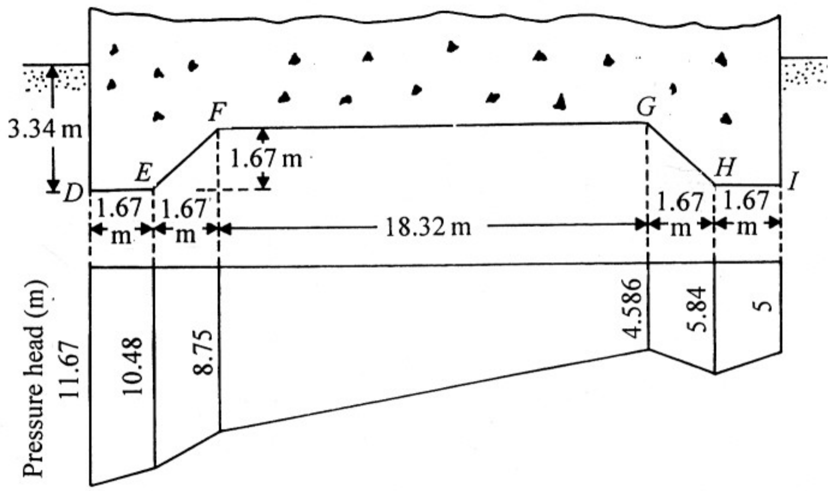
$$q = kH\left(\frac{N_f}{N_d}\right) = \left(\frac{0.002}{10^2}\times60\times60\times24\ \text{m/day}\right)(10)\left(\frac{5}{12}\right) = \mathbf{7.2\ m^3/m/day}$$

8.6 Refer to the flow net given in Problem 8.5 and the figure on the next page.

The flow net has 12 potential drops. Also, $H = 10$ m. So the head loss for each drop = (10/12) m. Thus,

Pressure head at $D = (10 + 3.34) - (2)(10/12) = 11.67$ m

Similarly,



Pressure head at E = (10 + 3.34) – (3)(10/12) = 10.84 m

Pressure head at F = (10 + 1.67) – (3.5)(10/12) = 8.75 m

Pressure head at G = (10 + 1.67) – (8.5)(10/12) = 4.586 m

Pressure head at H = (10 + 3.34) – (9)(10/12) = 5.84 m

Pressure head at I = (10 + 3.34) – (10)(10/12) = 5 m

The pressure heads calculated are shown in the figure. The hydraulic uplift force per unit length of the structure can now be calculated to be

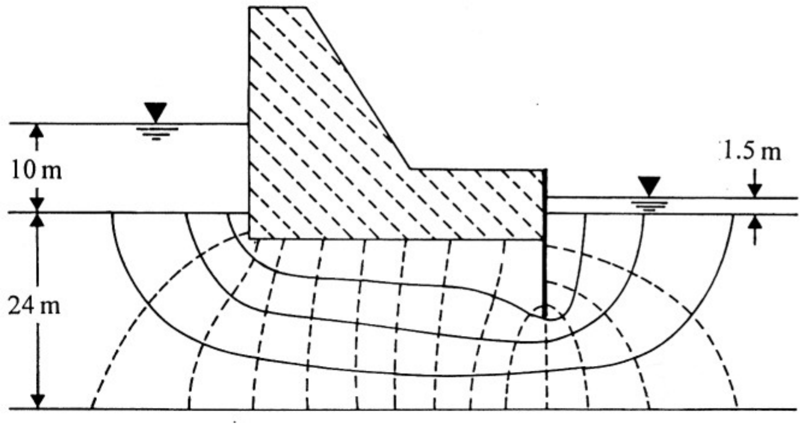
$$= \gamma_w(\text{area of the pressure head diagram})(1)$$

$$= \left[\begin{array}{l} \left(\dfrac{11.67+10.84}{2}\right)(1.67)+\left(\dfrac{10.84+8.754}{2}\right)(1.67) \\ +\left(\dfrac{8.75+4.586}{2}\right)(18.32)+\left(\dfrac{4.586+5.84}{2}\right)(1.67)+\left(\dfrac{5.84+5}{2}\right)(1.67) \end{array}\right]$$

$$= (9.81)(18.8+16.36+122.16+8.71+9.05)$$

$$= \mathbf{1717.5\ kN/m}$$

8.7 The flow net is shown. $N_f = 3$; $N_d = 5$.



8.8 For this case, $T' = 8$ m; $S = 4$ m; $H = H_1 - H_2 = 6$ m; $B = 8$ m; $b = B/2 = 4$ m.

a. $\dfrac{S}{T'} = \dfrac{4}{8} = 0.5$; $x = b - x' = 4 - 1 = 3$ m; $\dfrac{x}{b} = \dfrac{3}{4} - 0.75$; $\dfrac{b}{T'} = \dfrac{4}{8} = 0.5$

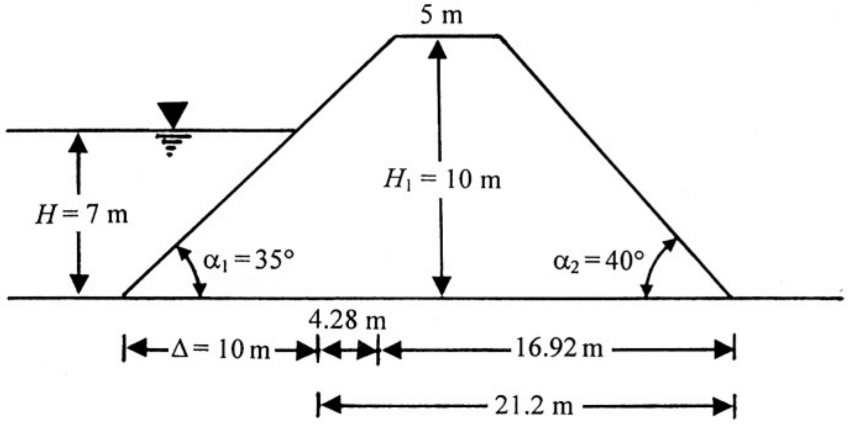
From Figure 8.11, $q/kH = 0.37$.

$$q = (0.37)\left(\frac{0.001}{10^2} \times 60 \times 60 \times 24\right)(6) \approx \mathbf{1.92\ m^3/m/day}$$

b. $\dfrac{S}{T'} = 0.5$; $\dfrac{b}{T'} = 0.5$; $x = b - x' = 4 - 2 = 2$ m; $\dfrac{x}{b} = \dfrac{2}{4} = 0.5$. So $q/kH = 0.4$.

$$q = (0.4)\left(\frac{0.001}{10^2} \times 60 \times 60 \times 24\right)(6) \approx \mathbf{2.07\ m^3/m/day}$$

8.9



$\alpha_1 = 35°$; $\alpha_2 = 40°$; $H = 7$ m; $\Delta = 7 \cot 35 = 10$ m. $0.3\Delta = 3$ m.

$$d = H_1 \cot \alpha_2 + L_1 + (H_1 - H)\cot \alpha_1 + 0.3\Delta$$

$$= (10)(\cot 40) + 5 + (10 - 7)\cot 34 + 3 = 24.2 \text{ m}$$

$$L = \frac{d}{\cos \alpha_2} - \sqrt{\frac{d^2}{\cos^2 \alpha_2} - \frac{H^2}{\sin^2 \alpha_2}} = \frac{24.2}{\cos 40} - \sqrt{\left(\frac{24.2}{\cos 40}\right)^2 - \left(\frac{7}{\sin 40}\right)^2}$$

$$= 1.94 \text{ m}$$

$$q = kL \tan \alpha_2 \sin \alpha_2 = \left[\left(\frac{3 \times 10^{-4}}{10^2}\right)(1.94)\right](\tan 40)(\sin 40)$$

$$= 3.139 \times 10^{-6} \text{ m}^3\text{/sec/m} \approx \mathbf{0.271\, m^3/m/day}$$

8.10 From Problem 8.9, d = 24.2 m; H = 7 m; α_2 = 40°

$$\frac{d}{H} = \frac{24.2}{7} = 3.46;\ m \approx 0.25 \text{ (Figure 8.14)};\ L = \frac{mH}{\sin \alpha_2} = \frac{(0.25)(7)}{\sin 40} = 2.72 \text{ m}$$

$$q = kL \sin^2 \alpha_2 = \left(\frac{3 \times 10^{-4}}{10^2}\right)(2.72)(\sin^2 40)$$

$$= 3.37 \times 10^{-6} \text{ m}^3\text{/sec/m} \approx \mathbf{0.291\, m^3/m/day}$$