Chapter 8

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

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

k_2 = **0.009 cm/sec**

8.2 The flow net is shown.

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

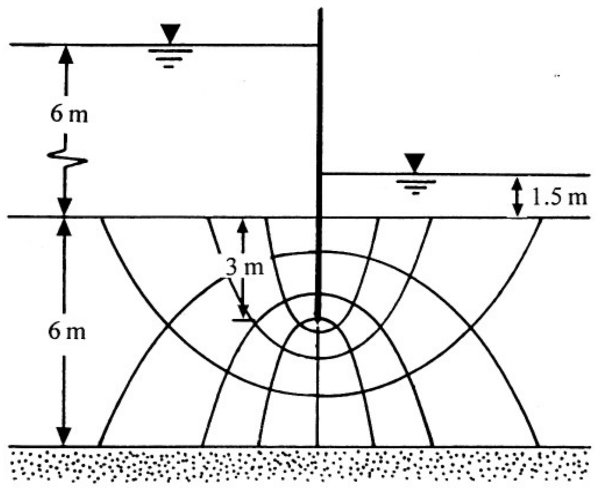
$H = H_1 - H_2$
$= 6.0 - 1.5 = 4.5$ m.

So

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

$$= 9 \times 10^{-6}\text{ m}^3\text{/m/sec}$$

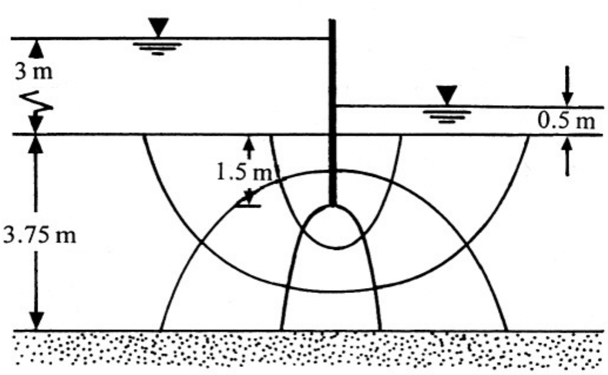
$$= \mathbf{77.76 \times 10^{-6}\text{ m}^3\text{/m/day}}$$



8.3 The flow net is shown.

$N_f = 3$; $N_d = 5$

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



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

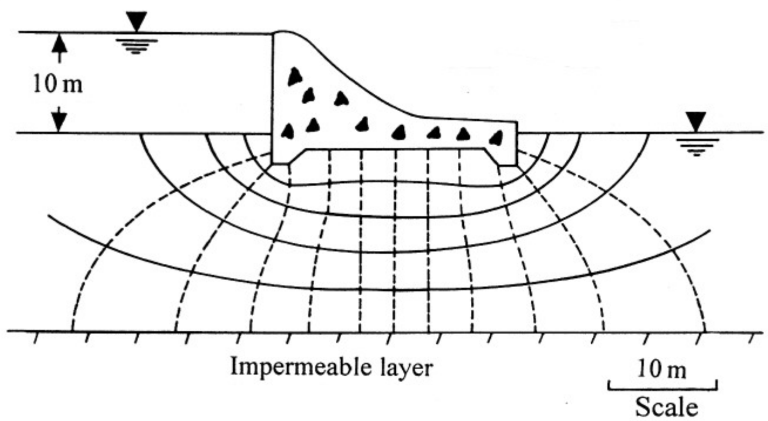
8.4 Based on the notations in Figure 8.10:

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

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

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

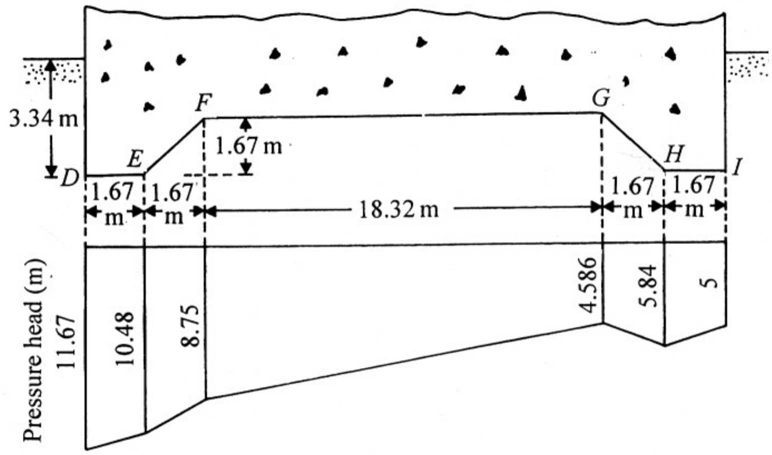
8.5 The flow net is shown.



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

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

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

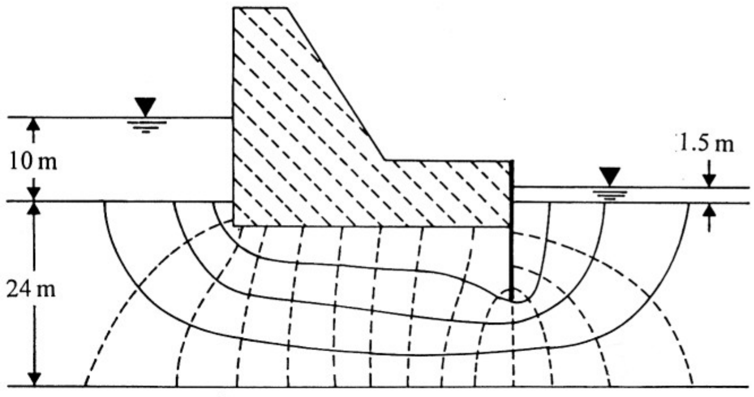
$$= \gamma_w(\text{area of the pressure head diagram})(1)$$

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

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

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

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



$$q = kH\left(\frac{N_f}{N_d}\right) = \left(\frac{10^{-3}}{10^2}\right)(10-1.5)\left(\frac{4}{14}\right) = (10^{-5})(8.5)\left(\frac{4}{14}\right)$$

$$= 2.429 \times 10^{-5} \text{ m}^3\text{/m/sec} \approx \mathbf{2.1\ m^3/m/day}$$

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

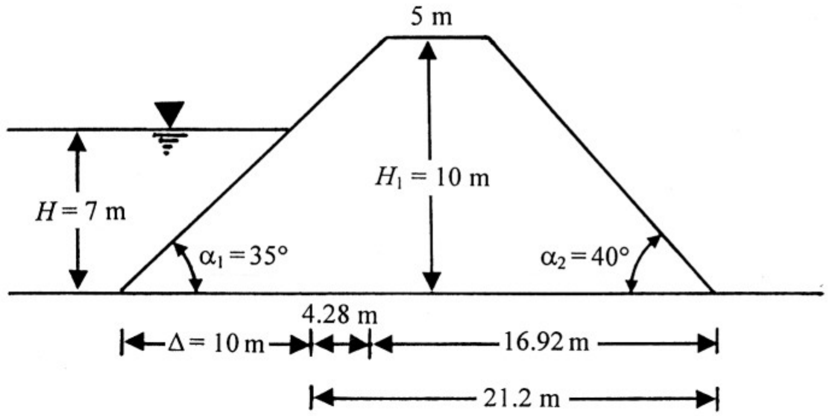
From Figure 8.11, $q/kH = 0.37$.

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

b. $\frac{S}{T'} = 0.5$; $\frac{b}{T'} = 0.5$; $x = b - x' = 4 - 2 = 2$ m; $\frac{x}{b} = \frac{2}{4} = 0.5$. 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.

$$d = H_1 \cot\alpha_2 + L_1 + (H_1 - H)\cot\alpha_1 + 0.3\Delta$$
$$= (10)(\cot 40) + 5 + (10-7)\cot 34 + 3 = 24.2 \text{ m}$$

$$L = \frac{d}{\cos\alpha_2} - \sqrt{\frac{d^2}{\cos^2\alpha_2} - \frac{H^2}{\sin^2\alpha_2}} = \frac{24.2}{\cos 40} - \sqrt{\left(\frac{24.2}{\cos 40}\right)^2 - \left(\frac{7}{\sin 40}\right)^2}$$
$$= 1.94 \text{ m}$$

$$q = kL\tan\alpha_2 \sin\alpha_2 = \left[\left(\frac{3\times10^{-4}}{10^2}\right)(1.94)\right](\tan 40)(\sin 40)$$
$$= 3.139\times10^{-6} \text{ m}^3\text{/sec/m} \approx \mathbf{0.271\ m^3/m/day}$$

8.10 From Problem 8.9, $d = 24.2$ m; $H = 7$ m; $\alpha_2 = 40°$

$$\frac{d}{H} = \frac{24.2}{7} = 3.46;\ m \approx 0.25 \text{ (Figure 8.14)}$$

$$L = \frac{mH}{\sin\alpha_2} = \frac{(0.25)(7)}{\sin 40} = 2.72 \text{ m}$$

$$q = kL\sin^2\alpha_2 = \left(\frac{3\times10^{-4}}{10^2}\right)(2.72)(\sin^2 40)$$
$$= 3.37\times10^{-6} \text{ m}^3\text{/sec/m} \approx \mathbf{0.291\ m^3/m/day}$$