Seepage and Effective Stress

Q1

From the question: Δh= 30cm

$l_A = l_B = l_C$ = 15cm

Calculation of the rate of water supply q in cm^3/h.

$q = Aki$

The flow is normal to the layers, Hence:

$$k = \frac{l_A + l_B + l_C}{\frac{l_A}{k_A} + \frac{l_B}{k_B} + \frac{l_C}{k_C}} = \frac{15+15+15}{\frac{15}{2\times10^{-2}} + \frac{15}{2\times10^{-3}} + \frac{15}{8\times10^{-5}}} = 2.31\times10^{-4}\left(cm/s\right)$$

and

$$i = \frac{\Delta h}{l_A + l_B + l_C} = \frac{30}{15+15+15} = 0.667$$

$$A = 10\times10 = 100\left(cm^2\right)$$

$$q = Aki = 100\times2.31\times10^{-4}\times0.667\times3600 = 55.47\left(cm/h\right)$$

Q2.

Figure 2 shows the flow net diagram, from which N_f= 3.5 and N_d = 9. The overall loss in total head is 3.00m. Then

$$q = kh\frac{N_f}{N_d} = 5\times0^{-5}\times.00\times\frac{3.5}{9} = 5.8\times10^{-5}\left(m^3/s/m\right)$$

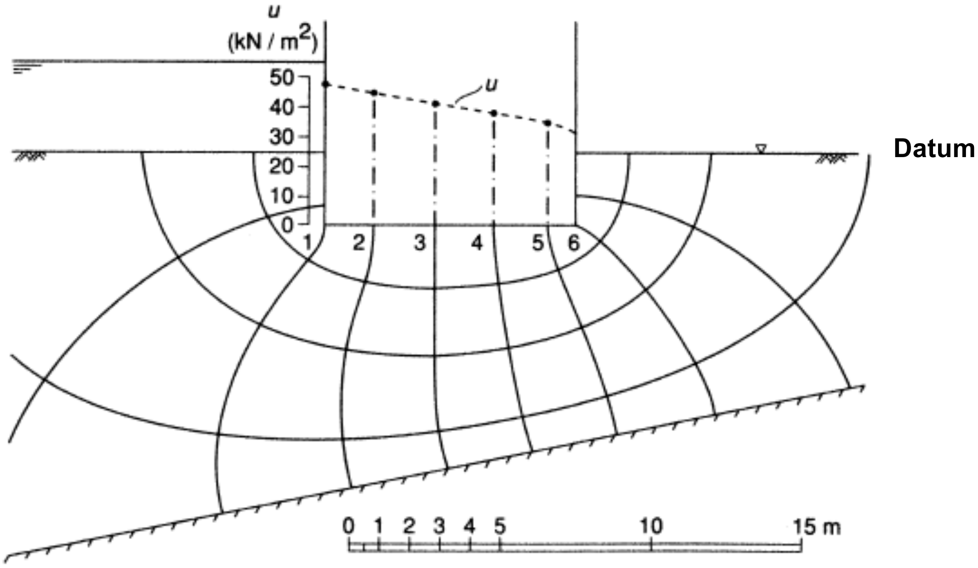
The pore water pressure is determined at the points of intersections of the equipotential with the base of the structure. The total head (*h*) at each point is obtained from the flow net. The elevation head (*z*) at each point on the base of the structure is -2.50m. The calculations are below and the distribution of pressure is plotted to scale in the figure.

Point	***h* (*m*)**	***h-z* (*m*)**	***u* = γ_w (*h* - *z*) (*kN/m²*)**
1	2.33	4.83	47
2	2.00	4.50	44
3	1.67	4.17	41
4	1.33	3.83	37
5	1.00	3.50	34
6	0.67	3.17	31

e.g. for point 1:

$$h_1 = \frac{n_1}{n_d}\times h == \frac{7}{9}\times3 = 2.33\left(m\right)$$

$$h_p = h_1 - z_1 = 2.33 - \left(-2.5\right) = 4.83\left(m\right)$$



The uplift force on the base of the structure is equal to the area of the pressure diagram and is 316 kN per unit length.

Q3.

Given:

$$\rho_{sat(clay)} = 1925\, kg/m^3$$
$$\gamma_{sat(clay)} = \frac{1925 \times 9.81}{1000} = 18.88\, kN/m^3$$

At point A

$$\sigma_A = (10 - 7.2)\gamma_{sat(clay)} + h\gamma_w = 2.8 \times 18.88 + h\gamma_w = 52.86 + h\gamma_w\,(kPa)$$
$$u_A = 6\gamma_w = 6 \times 9.81 = 58.86\,(kPa)$$

For heave(For clay stability)

$$\sigma_A - u_A = 0$$
$$\sigma_A = u_A$$
$$52.86 + h\gamma_w = 58.86$$
$$h = \frac{58.86 - 52.86}{9.81} = 0.61m$$

Q4.

Step 1: Calculate the unit weights;

0 - 2 m

S= 40% = 0.4 ; w= 0.05

e=wG_s/S =$\frac{0.05 \; x \; 2.7}{0.4}$=0.34

γ = $G_s\frac{(1+w)}{(1+e)}\gamma_w$ = $\frac{2.7\;(1+0.05)}{1+0.34} \times 9.8 = 20.7\; kN/m^3$

2– 5.4 m

S=1; w= 0.12

e= wG_s= 0.12 x 2.7 = 0.32

γ= ($\frac{Gs+e}{1+e}$) γ_w = ($\frac{2.7 \; x \; 0.32}{1+0.32}$) x 9.8 = 22.4 kN/m^3

5.4 – 20.6 m

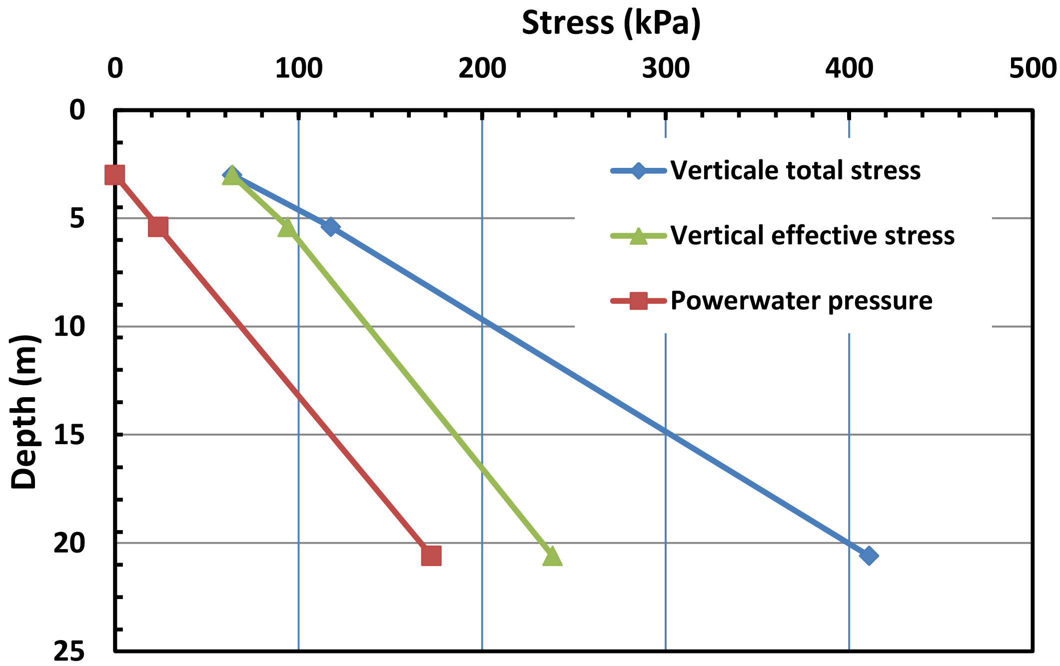
S=1; w= 0.28

e= wG_s= 0.28 x 2.7 = 0.76

γ= ($\frac{Gs+e}{1+e}$) γ_w = ($\frac{2.7 \; x \; 0.76}{1+0.76}$) x 9.8 = 19.3 kN/m^3

Step 2: calculate the stress table or spreadsheet

Depth (m)	**Thickness (m)**	**σ (KPa)**	**u (kPa)**	**σ´ = σ - u (kPa)**
3	3	20.7 x 2 + 22.4 x 1 = 63.8	0	63.8
5.4	2.4	63.8 + 22.4 x 2 = 117.6	2.4 x 9.8= 23.5	94.1
20.6	15.2	117.6 + 19.3 x 15.2 = 411	23.5 + 15.2 x 9.81 = 172.5 or 17.6 x 9.8 = 172.5	238.5


Stress (kPa)
0
100
200
300
400
500
Depth (m)
0
5
10
15
20
25
Verticale total stress
Vertical effective stress
Powerwater pressure