Soil Mechanics

Midterm – Solution

Question 1:

- Find k_{eq}

$$k_{1,2} = \frac{H}{\frac{H_1}{K_1} + \frac{H_2}{K_2}} = \frac{17.5}{\frac{7.5}{2x10^{-3}} + \frac{10}{1x10^{-3}}} = 1.27x10^{-3}\ cm/s$$ 2 points

$$k_{2,3} = \frac{1}{H}(k_2\ H_2 + k_3 H_3) = \frac{1}{10}\left(1x10^{-3} * 5 + \frac{2}{3}x10^{-3} * 5\right) = 0.83x10^{-3} cm/s$$ 3 points

$$k_{eq} = \frac{H}{\frac{H_{1,2}}{K_{1,2}} + \frac{H_{2,3}}{K_{2,3}} + \frac{H_4}{K_4}} = \frac{17.5 + 30 + 15}{\frac{17.5}{1.27x10^{-3}} + \frac{30}{0.83x10^{-3}} + \frac{15}{2x10^{-3}}} = 1.09x10^{-3}\ cm/s$$ 3 points

- Find water supply flow rate

$$q_{eq} = k_{eq} i\ A = 1.09x10^{-3} * \frac{77.4 - 57.4}{7.5 + 10 + 30 + 15} * 10 * 10 = 0.349x10^{-3}\ cm^3/s$$ 3 points

- Find flow rate through soil 3

$$q_{eq} = q_{2,3} = k_{2,3} i_{2.3} A \rightarrow 0.349x10^{-3} = 0.83x10^{-3} *\ i_{2,3} * 10 * 10 \rightarrow i_{2.3} = 0.42 = i_3$$ 3 points

$$q_3 = k_3\ i_3\ \ A_3 = \frac{2}{3}x10^{-3} * 0.42 * 5 * 10 = 0.14x10^{-3}\ cm/s$$ 3 points

- Find total head, elevation head, and pore water pressure At points A, B, C
  - At point A:

    Total head = 77.4 cm

    Elevation head = 62.4 cm 5 points

    Pressure head = 15 cm $\rightarrow u_A = h_p * \gamma_w = \frac{15}{100} * 10 = 1.5\ kPa$

- At point B:

$q_{eq} = q_1 = k_1 i_1 A \rightarrow 0.349x10^{-3} = 2x10^{-3} * i_1 * 10 * 10 \rightarrow i_1 = 0.175$ 3 points

$i_1 = \frac{h_A - h_B}{L_{A \rightarrow B}} \rightarrow h_B = 76.09\ cm = Total\ head$

Elevation head = 54.9 cm 5 points

Pressure head = 21.19 cm $\rightarrow u_B = h_p * \gamma_w = \frac{21.19}{100} * 10 = 2.12\ kPa$

- At point C:

Total head = 57.4 cm

Elevation head = 39.7 cm 5 points

Pressure head = 17.7 cm $\rightarrow u_A = h_p * \gamma_w = \frac{17.7}{100} * 10 = 1.77\ kPa$

	Total head (cm)	Elevation head (cm)	Pore-water pressure (kPa)
A	77.4	62.4	1.5
B	76.09	54.9	2.12
C	57.4	37.7	1.77

Question 2:

- Find flow rate

  $N_d = 11$

  $N_f = 4$

  2 points

  $$q = k\frac{H}{N_d}N_f = 4x10^{-3} * 10^{-2} * \frac{6}{11} * 4 = 8.73x10^{-5}\ m^3/s/m$$

  2 points

  $$q = 8.73x10^{-5} * 60\frac{s}{min} * 60\frac{min}{hour} * 24\frac{hour}{day} = 7.54\ m^3/day\ /m$$

  2 points

- Is the weight of the dam enough to resist the uplift force?

  Each head drop = 6/11 = 0.545 m

  At point 1: Total head = 15 + 6 – head drop = 20.455 m

  Elevation head = 15-1 = 14 m

  4 points

  Pressure head = 6.455 m → pore pressure = u_1 = 64.55 kPa

  Since all points on the same elevation, the head drop is a drop in the pressure head

  The pressure will drop 0.545*10 = 5.45 kPa for each subsequent point

  5 points

  The pressure distribution under the dam is shown in the figure below

  $$f_{uplift} = \frac{1}{2}(64.55 + 59.1)(0.45) + \frac{1}{2}(59.1 + 20.95)(1.3 * 7) + \frac{1}{2}(20.95 + 15.5)(0.45)$$

  6 points

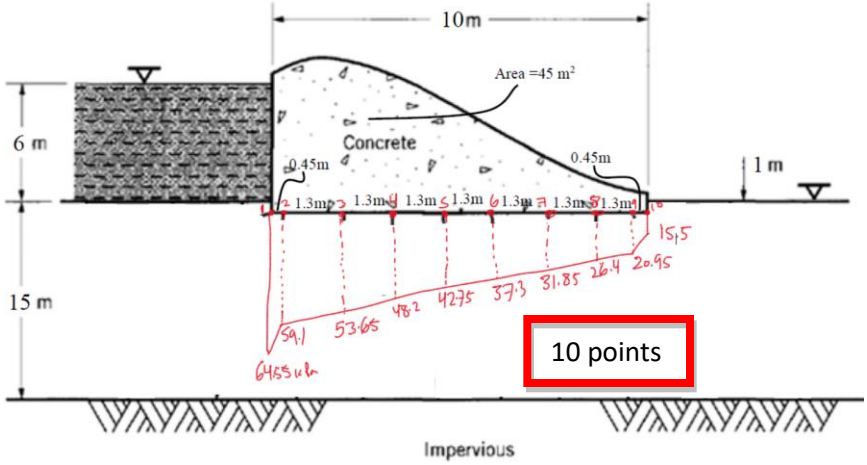
  $$f_{uplift} = 400.25\ kN$$

  $$W_{dam} = 45 * 24 = 1080\ kN \gg f_{uplift} \dots\dots\dots OK$$

  2 points

  $$F.S_{uplift} = \frac{1080}{400.25} = 2.7$$

  2 points



10 points