



CVG 3109
SOIL MECHANICS - I
MIDTERM EXAM

Length of Examination: 1hr 20 min
Professor: Won Taek Oh

17th Oct, 2010 (11:30 AM to 12:50 PM)
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Family Name: _____

Other Names: _____

Student Number: _____

Signature _____

- (i) This is a closed book exam. No textbooks are allowed
- (ii) Formula sheet is available on last pages of this question paper
- (iii) If you do not understand a question, clearly state an assumption and proceed.**
- (iv) Non programmable calculators are permitted
- (v) Questions have the values shown next to the question.
- (vi) Marks will be taken out for missing units and labels.**
- (vii) Answers should be succinct.

At the end of the exam, when time is up:

- Stop working and turn your exam upside down.
- Please remain silent.
- Do not move or speak until **ALL** exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

<u>Question</u>	<u>Max Marks</u>	<u>Marks Awarded</u>
1	10	
2	30 (15 + 5 + 10)	
3	30 (15 + 15)	
4	15	
5	15	
Total	100%	

Question 1 (10 Marks)

Sol.

Effective stress for initial condition

$$\sigma' = \sigma - u_s$$

Effective stress for final condition

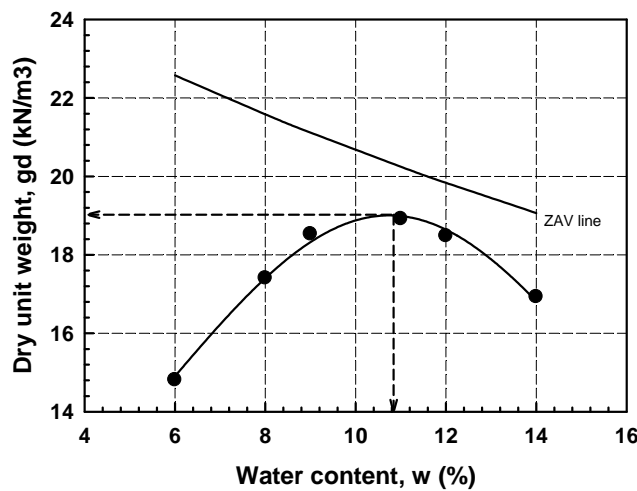
$$\begin{aligned} \sigma' &= (\sigma + \Delta\sigma) - (u_s + u_e) \\ &= \sigma - u_s \quad (\because \Delta\sigma = u_e) \end{aligned}$$

\therefore Effective stress does not change

Question 2 (30 Marks)

Sol. (a) and (b):

w (%)	γ_t (kN/m ³)	γ_d (kN/m ³)	γ_d (kN/m ³) at S = 100%
6	15.7	14.8	22.6
8	18.8	17.4	21.6
9	20.2	18.5	21.1
11	21	18.9	20.2
12	20.7	18.5	19.8
14	19.3	16.9	19.1



$$\gamma_{d(max)} = 19 \text{ kN/m}^3 \text{ at OMC} = 10.8 \%$$

$$\text{ZAV: } \gamma_d = \frac{G_s}{1+e} \gamma_w = \frac{G_s}{1+G_s w} \gamma_w$$

Sol. (c):

$$w = 10.8\%, \gamma_d = 0.9\gamma_{d(max)} = 0.9 \times 19 = 17.1 \text{ (kN/m}^3\text{)}$$

$$e = \frac{G_s}{\gamma_d} \gamma_w - 1 = \frac{2.67}{17.1} \times 9.81 - 1 = 0.53$$

$$\gamma_t = \gamma_d \times (1 + w) = 17.1 \times 1.108 = 18.95 \text{ kN / m}^3$$

$$Se = G_s w$$

$$w = \frac{e}{G_s} = \frac{0.53}{2.67} = 19.85\% (S = 100\%)$$

$$\gamma_{sat} = \frac{G_s + Se}{1 + e} \gamma_w = \frac{2.67 + 0.53}{1 + 0.53} \times 9.81 = 20.52 \text{ kN / m}^3$$

amount of water =

$$\gamma_{sat} - \gamma_t = 20.52 - 18.95 = 1.57 \text{ (kN / m}^3\text{)}$$

Question 3 (30 Marks)

Sol.:

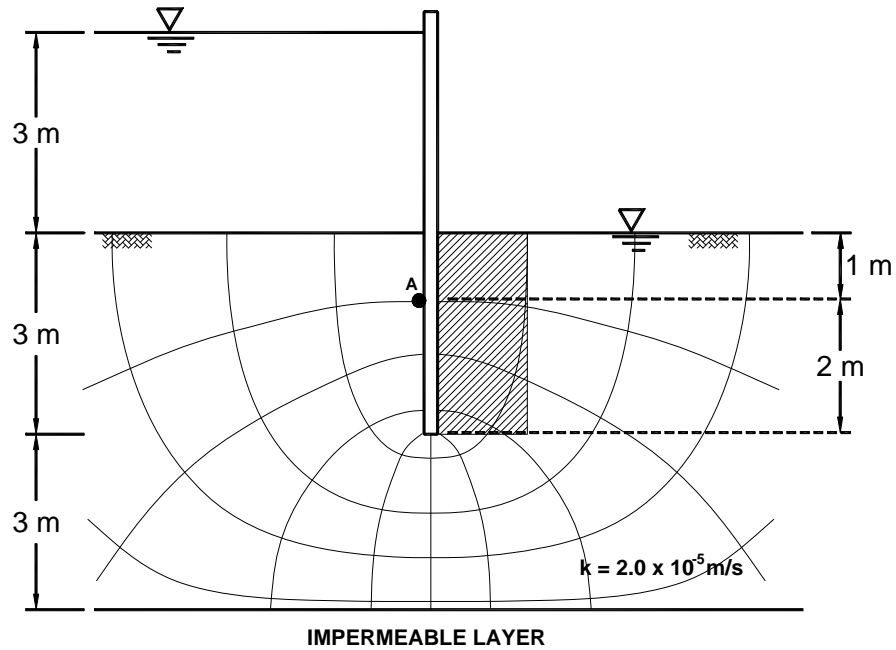


Figure 1

$$\sigma = 3 \times \gamma_w + 2 \times \gamma_{sat} = 3 \times 9.81 + 1 \times 20 = 49.4 \text{ kPa}$$

Pressure head (PH) = Total head – Elevation head

$$= \left(3 - \frac{3}{10} \times 1 \right) - (-1) = 3.7 \text{ (m)}$$

$$u = PH \times \gamma_w = 3.7 \times 9.81 = 36.3 \text{ kPa}$$

$$\sigma' = \sigma - u = 49.4 - 36.3 = 13.1 \text{ kPa}$$

Question 4 (15 Marks)

Sol.:

EL 0 ~ -2 m

$$S_e = G_s w$$

$$e = \frac{G_s w}{S} = \frac{2.7 \times 0.05}{0.4} = 0.338$$

$$\gamma_t = \frac{G_s + S_e}{1 + e} \gamma_w = \frac{2.7 + 0.4 \times 0.338}{1 + 0.338} \times 9.81 = 20.8 \text{ kN} / \text{m}^3$$

EL -2 ~ - 6.5 m

$$e = \frac{G_s w}{S} = \frac{2.7 \times 0.5}{1} = 1.35$$

$$\gamma_t = \frac{G_s + S_e}{1 + e} \gamma_w = \frac{2.7 + 1 \times 1.35}{1 + 1.35} \times 9.81 = 16.9 \text{ kN} / \text{m}^3$$

Effective stress at EL -2 m

$$\sigma = \sigma' = 20.8 \times 2 = 41.6 \text{ (kPa)}$$

Effective stress at EL -3.5 m

$$\sigma = 41.6 + 16.9 \times 1.5 = 66.95 \text{ (kPa)}$$

Effective stress at EL -6.5 m

$$\sigma = 66.95 + (16.9 - 9.81) \times 3 = 88.22 \text{ (kPa)}$$

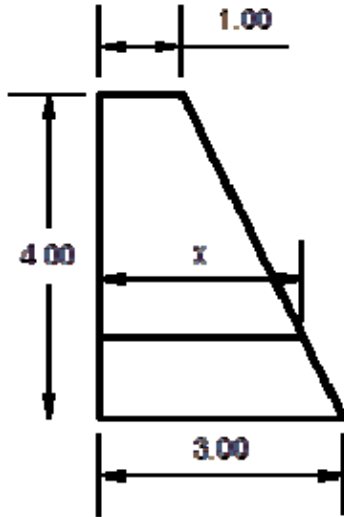
Question 4 (15 Marks)

Sol.:

Total stress

$$\sigma = 1 \times \gamma_w + 3\gamma_{sat} = 1 \times 9.81 + 3 \times 19.5 = 68.3 \text{ kPa}$$

Pore-water pressure



Using proportional expression

$$x = 2.5$$

$$u = (2.5 + 3)\gamma_w = 54 \text{ kPa}$$

$$\sigma' = \sigma - u = 68.3 - 54 = 14.3 \text{ kPa}$$

Formula Sheet

Phase relationships:

Unit weight of soil:

$$\gamma = \frac{W}{V} = \frac{(V_w + V_s G_s) \gamma_w}{1 + e} = \frac{(Se + G_s) \gamma_w}{1 + e}$$

Submerged unit weight: $\gamma_{sub} = \frac{(G_s - 1) \gamma_w}{1 + e}$

Dry unit weight:

$$\gamma_d = \frac{W_s}{V} = \frac{G_s}{1 + e} \gamma_w = \frac{\gamma}{1 + w}$$

$$Se = w G_s$$

$$A = n(1 - S)$$

Effective stress: $\sigma' = \sigma - u_w$

Effective stress on downward seepage:

$$\sigma' = \gamma_{sub} z + jz = \gamma_{sub} z + iz \gamma_w$$

Effective stress on upwards seepage:

$$\sigma' = \gamma_{sub} z - jz = \gamma_{sub} z - iz \gamma_w$$

Critical hydraulic gradient:

$$\sigma' = 0 = \gamma_{sub} z - iz \gamma_w \Leftrightarrow i_c = \frac{\gamma_{sub}}{\gamma_w}$$

$$i_c = \frac{(G_s - 1) \gamma_w}{1 + e} \cdot \frac{1}{\gamma_w} = \frac{(G_s - 1)}{1 + e}$$

Permeability:

Total head: $h = \frac{u}{\gamma_w} + \frac{v^2}{2g} + Z$

Hydraulic gradient: $i = \frac{\Delta h}{L}$

$$v = ki \text{ \& } q = vA$$

Darcy's law: $\Leftrightarrow Q = kiAt = k \cdot \frac{\Delta h}{L} \cdot At$

Equivalent hydraulic conductivity:

$$k_{H(eq)} = \frac{k_{H_1} H_1 + \dots + k_{H_n} H_n}{H_1 + \dots + H_n}$$

$$k_{V(eq)} = \frac{H_1 + \dots + H_n}{\left(\frac{H_1}{k_{V_1}}\right) + \dots + \left(\frac{H_n}{k_{V_n}}\right)}$$

Seepage:

Total head = Pressure head + Elevation

$$\Delta h = \frac{h_w}{N_d}$$

Seepage in a flow net:

$$q = k \cdot h_w \cdot \frac{N_f}{N_d}$$

Pore water pressure (kPa):

$$u_p = \gamma_w [h_p - (-z_p)] = \gamma_w (h_p + z_p)$$

Seepage force: $J = i \gamma_w V$

Seepage pressure: $j = \frac{J}{V} = i \gamma_w$

Effective stress: