Student Name: ---------------------------------; Student Number: -------------------------

This mid-term quiz consists of 5 pages. Please check that you have a complete paper.

THE UNIVERSITY OF BRITISH COLUMBIA
Department of Civil Engineering
MID-TERM EXAMINATION No. 2 – NOVEMBER 07, 2011
SOIL MECHANICS II - CIVL 311
Instructor: Dr. D. Wijewickreme

Time: 45 Minutes

1. Closed book exam. Formulae provided on pages 3 through 5.
2. Answer both the questions.
3. Make any reasonable assumptions, where appropriate, to answer the questions. Assume that the unit weight of water is 9.8 kN/m^3.
4. In your answers, be brief and to the point. Show ***all work*** for full credit.
5. Write your answers on the blank pages provided separately. Use sketches whenever possible.
6. Show all steps of your calculation to receive full marks. (Maximum attainable marks = 22).
7. Remember to write your name on the answer script and also ***return the question paper*** with your answers.

Marks **Question 1**

(6) A rectangular foundation, 2.0 m x 3.0 m, is located at a depth of 1.0 m below the ground surface in a saturated normally consolidated clayey silt deposit. Laboratory testing conducted on an undisturbed sample (obtained from a depth considered representative for the design of the above foundation) of this clay deposit indicated an unconfined compressive strength of 60 kPa and a saturated density of 18 kN/m^3. Determine the ultimate net bearing capacity (q_u) of the foundation assuming fully centric loading.

Marks **Question 2**

(16) A schematic cross section of a water filter system is illustrated in the figure below where a clay zone and uniform homogeneous sand zone is constrained between vertical wall segments constructed along the lines CAB and C’A’B’. The sand zone is held at the bottom using a horizontal thin metal plate with fine perforations (along BB’). You have been informed that water flow would enter the top of sand filter at the boundary AA’, and then exit from the bottom boundary of the filter (BB’) into a constant water head reservoir.

A standpipe piezometer has been installed at A’ to determine the pore water pressure conditions at that point. Due to other engineering considerations, the wall segment A’B’ is designed to have the flexibility to move horizontally outwards (to the right). If such lateral movement occurs, determine the active lateral effective earth pressure distribution and pore water pressure distribution ONLY on the wall segment A’B’ (Assume Rankine theory can be used to compute lateral active earth pressures. No need to calculate total force on A’B’. No need to calculate pressures or total force on the wall segment C’A’).

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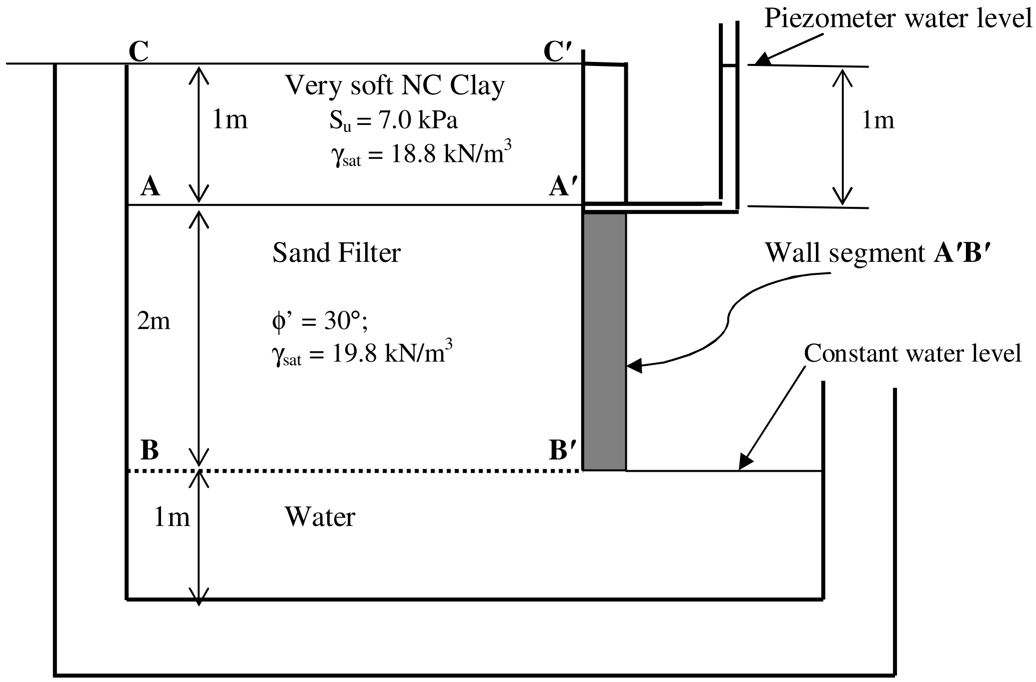

NOTE: Not to scale; assume dimension AA' is wide enough to develop active Rankine conditions in the soil when the wall segment A'B' moves rightward.

EQUATIONS

Computation of static effective stresses in a soil mass

$\sigma'_z = \Sigma \gamma_i h_i$;
γ_i = Bulk unit weight of i th layer of soil;
h_i = Thickness of i th layer of soil;
σ'_z = Vertical effective stress;
$\sigma' = \sigma - u$; u = Pore water pressure

Under static groundwater (no flow) conditions: $u = \gamma_w z$
With groundwater seepage (with flow) conditions at any given point:
$H_{total} = H_{elev} + H_{pwp}$; $H_{pwp} = u/\gamma_w$
H_{total} = Total Head; H_{elev} = Elevation head with respect to a pre-defined datum;
H_{pwp} = Pore water pressure head

Lateral Earth Pressures

(i) Effective stress analysis

Coefficient of active earth pressure = K_a
Effective lateral earth pressure under active conditions = $(\sigma'_x)_a$
Effective vertical stress at a given depth = σ'_z

$(\sigma_x')_a = K_a \sigma_z'$

$$\frac{(\sigma_x')_a}{(\sigma_z')} = \frac{1-\sin\phi'}{1+\sin\phi'} = K_a$$

Coefficient of passive earth pressure = K_p
Effective lateral earth pressure under passive conditions = $(\sigma'_x)_p$
Effective vertical stress at a given depth = σ'_z

$(\sigma_x')_p = K_p \sigma_z'$

$$\frac{(\sigma_x')_p}{(\sigma_z')} = \frac{1+\sin\phi'}{1-\sin\phi'} = K_p$$

(ii) Total stress analysis:

Active earth pressure = $(\sigma_x)_a$
Total vertical stress at a given depth = σ_z

$$(\sigma_x)_a = (\sigma_z) - 2S_u$$

Note: At tension crack depth level, Z_{crack} below the ground surface, $(\sigma_x)_a = 0$.

Passive earth pressure = $(\sigma_x)_p$
Total vertical stress at a given depth = σ_z

$$(\sigma_x)_p = (\sigma_z) + 2S_u$$

Bearing capacity of Shallow Foundations

Effective Stress Analysis (ESA)

$$q_u = \gamma D_f (N_q - 1)(s_q d_q w_q) + 0.5\gamma B' N_\gamma (s_\gamma d_\gamma w_\gamma)$$

Total Stress Analysis (TSA)

$$q_u = 5.14 s_u (s_c d_c)$$

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Definition of the factors to account for the different variations:

s_q, s_γ, s_c - Shape of Footing

d_q, d_γ, d_c - Depth of Footing Embedment

w_q, w_γ - Groundwater level

Undrained shear strength = S_u

$$N_q = e^{\pi \tan\phi'_p} \tan^2\left(45^\circ + \frac{\phi'_p}{2}\right); \ \phi'_p \text{ in degrees}$$

Caquot and Kerisel (1953)[2]: $N_\gamma = 2(N_q + 1)\tan\phi'_p$; ϕ'_p in degrees

Meyerhof (1976): $N_\gamma = (N_q - 1)\tan(1.4\phi'_p)$; ϕ'_p in degrees

Davis and Booker (1971)[3]:

smooth foundation, $N_\gamma = 0.0663\exp(9.3\phi'_p)$; ϕ'_p in radians

rough foundation, $N_\gamma = 0.1054\exp(9.6\phi'_p)$; ϕ'_p in radians

Ueno et al. (1998)[4]:

rough foundation, $N_\gamma = 0.477\exp(6.52\phi'_p)$; ϕ'_p in radians

Note: Unless specifically stated otherwise, use Davis and Booker (1971) for rough foundations given above to determine N_γ.

Effective Footing Dimensions

$$B' = B - 2e_B$$

$$L' = L - 2e_L$$

Definition of the factors to account for the different variations:

s_q, s_γ, s_c - Shape of Footing

d_q, d_γ, d_c - Depth of Footing Embedment

w_q, w_γ - Groundwater level

Shape factors:

$S_q = 1 + (B'/L')*\tan(\phi'_p)$
$S_\gamma = 1 - 0.4 * (B'/L')$
$S_c = 1 + 0.2\,(B'/L')$

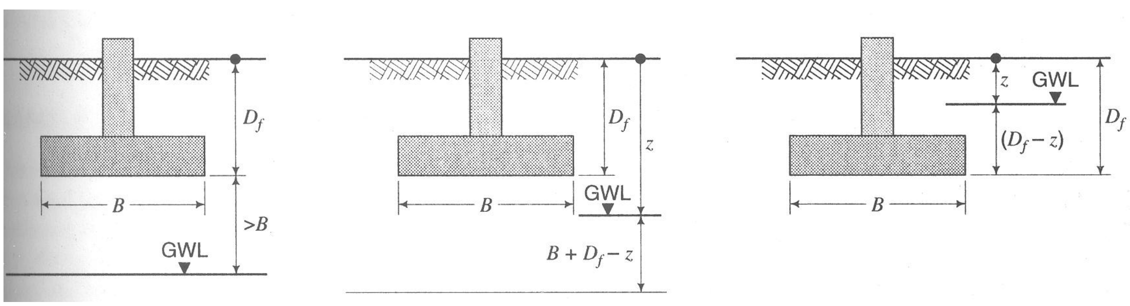
Embedment factors:

$d_q = 1 + 2\tan(\phi'_p)*(1 - \sin\phi'_p)^2 * \tan^{-1}(D_f/B')$, for $(D_f/B') > 1$
$d_q = 1 + 2\tan(\phi'_p)*(1 - \sin\phi'_p)^2 * (D_f/B')$, for $(D_f/B') \le 1$

$d_\gamma = 1$

$d_c = 1 + 0.33*\tan^{-1}(D_f/B')$, for $(D_f/B') > 1$
$d_c = 1 + 0.33*(D_f/B')$, for $(D_f/B') \le 1$

Ground water factors:



Case 1: $Z > (B+D_f)$ Case 2: $(B+D_f) > Z > D_f$ Case 3: $Z < D_f$

$$Case\_1: w_q = 1; w_\gamma = 1$$

$$Case\_2: w_q = 1; w_\gamma = \frac{(z - D_f)}{B} + \frac{\gamma'}{\gamma_{sat}}\left(1 + \frac{D_f}{B} - \frac{z}{B}\right)$$

$$Case\_3: w_q = \frac{z}{D_f} + \frac{\gamma'}{\gamma_{sat}}\left(1 - \frac{z}{D_f}\right); w_\gamma = \frac{\gamma'}{\gamma_{sat}}$$