NATIONAL EXAMINATIONS –May 2019
07-BLD-A6 GEOTECHNICAL MATERIALS AND ANALYSIS

3 HOURS DURATION

NOTES:

1. This is a **closed book** examination.
2. Read all questions carefully before you answer
3. Should you have any doubt regarding the interpretation of a question, you are encouraged to complete the question submitting a clear statement of your assumptions.
4. The total exam value is 100 marks
5. One of two calculators can be used: Casio or Sharp approved models.
6. Drawing instruments are required.
7. All required charts and equations are provided at the back of the examination.
8. YOU MUST RETURN ALL EXAMINATION SHEETS.

SECTION A
ANSWER ALL QUESTIONS

Question 1: **(4 x 5 = 20 marks)**

State the correct answer. Also, provide reasons to justify the statement in your answer book along with the question number. Have all your answers to this question at the same place.

(a)	Which one of the following soil density values will be the highest (i) Dry density (ii) Moist density (iii) Saturated density (iv) Submerged density
(b)	Assume you are swimming in a swimming pool at a depth of 4m below the top surface of water. One of the following statements is true with respect to pressure on your body: (i) There is no pore-water pressure as there are no pores in water. (ii) The total stress is equal to the pore-water pressure (iii) The effective stress is equal to the pore-water pressure (iv) None of the above are correct
(c)	The effective shear strength parameters, $c'$and ϕ' values can be determined using the following tests (i) **CD** tests (Direct shear equipment) (ii) **CU** triaxial tests with pore-water pressure measurements (iii) **CD** triaxial tests without pore-water pressure measurement (iv) All of the above tests
(d)	Which one of the following square footings placed at depth of 1.5 m in a saturated stiff clay will have a higher bearing capacity under undrained loading conditions. Hint: $q_{ult} = c_u N_c + \gamma D N_q + 0.5\ \gamma B N_\gamma$ (i) 1m x 1m (ii) 1.5m x 1.5m (iii) 2 x 2m (iv) all of them have the same bearing capacity
(e)	Which one of the following soils will have a higher coefficient of permeability (i) Uniformly graded sand (ii) Well-graded sand (iii) Gap-graded sand (ii) All sands have approximately the same coefficient of permeability

Question 2: **(10 marks)**

For a moist soil, given that volume = 5660 cm^3; mass = 10.4 kg; moisture content = 10%; G_s = 2.7, calculate the following:

a. Moist density (kg/m^3)

b. Dry density (kg/m^3)

c. Porosity
d. Degree of Saturation (%)
e. Volume occupied by water (m^3)

Question 3: **(10 marks)**

Explain how the various stages shown in **Figure 1** can be compared with the consolidation process in saturated clay using the spring, piston, and valve (note both the closed and open positions of the valve)).

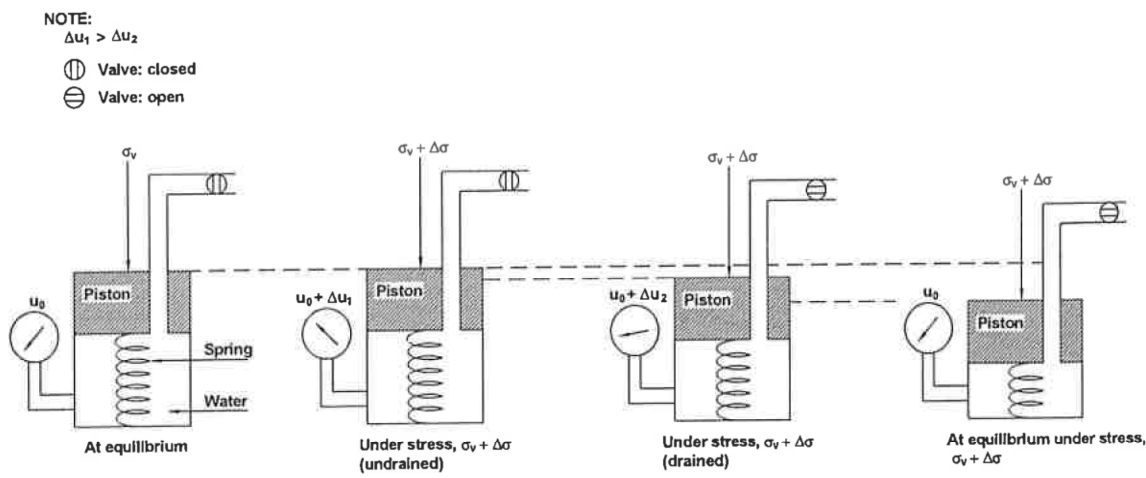


Figure 1

SECTION B

ANSWER **ANY THREE** OF THE FOLLOWING FOUR QUESTIONS

Question 4: **(Value: 20 marks)**

For a sheet piling driven 6.00m into a stratum of soil 8.60m thick (see **Figure 2**).

(i) Establish the flow net by drawing flow lines and equipotential lines (Follow all the rules in drawing flow nets).

(ii) Determine the total volume of water, q flowing under the piling per unit time per unit length in m^3/s. Given that the coefficient of permeability of the soil, $k = 1.5\times10^{-5}$ m/s.

(iii) Calculate effective stress at **Point A**.

Candidate name: ______________

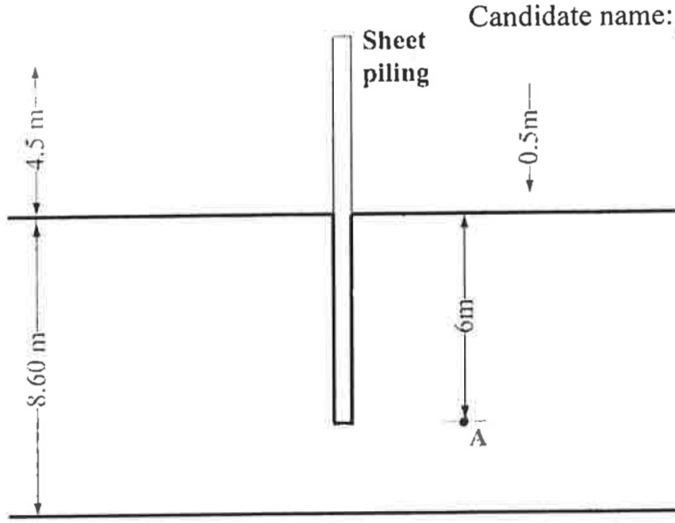


Figure 2

Question 5: **(Value: 20 marks)**

(i) What are common assumptions and limitations of elastic theories? Draw the typical variation of vertical stress with depth and variation of vertical stress with horizontal distance at three different depths due to a point load.

(ii) A rectangular foundation subjects the subgrade to a net contact stress of 215 kN/m^2. Determine the vertical stress for a point located outside the plan area of the foundation at **O** (see **Figure 3) at a depth of 2 m.** Use two methods (i) *m* and *n* coefficients method (ii) Newmark's method.

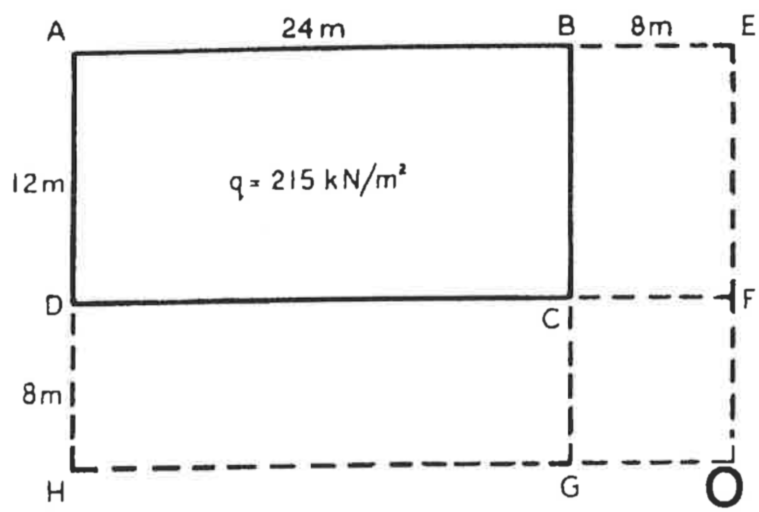


Figure 3

Question 6: **(Value: 20 marks)**

(i) The effective shear strength parameters for a fully saturated clay are known to be $c'=20\ kN/m^2$ and $\phi'=30^0$. The principal stress difference at failure was $180\ kN/m^2$ when the specimen was tested under unconsolidated-undrained conditions in a triaxial test on a specimen of the same clay with an all-round pressure of $100\ kN/m^2$. From the above information, determine the pore-water pressure in the soil specimen.

(ii) Can you use the unconsolidated undrained triaxial shear strength test results to determine the long term stability of an earthen structure constructed with fine-grained soil? State whether your answer is YES or NO to this question providing justification.

Question 7: **(Value: 20 marks)**

A soil profile is shown in **Figure 4**. The uniformly distributed load on the ground surface is $\Delta\sigma = 200$ kN/m^2. In the shown soil profile $H_1 = 2$ m, $H_2 = 2$ m, and $H_3 = 4$ m. For the sand, $\gamma_{dry} = 14.6$ kN/m^3, $\gamma_{sat} = 17.3$ kN/m^3 and for the clay, $\gamma_{sat} = 19.3$ kN/m^3. The liquid limit, LL = 50%, the specific gravity of the clay is 2.7 and the void ratio = 0.9. Estimate the primary settlement of the normally consolidated clay layer.

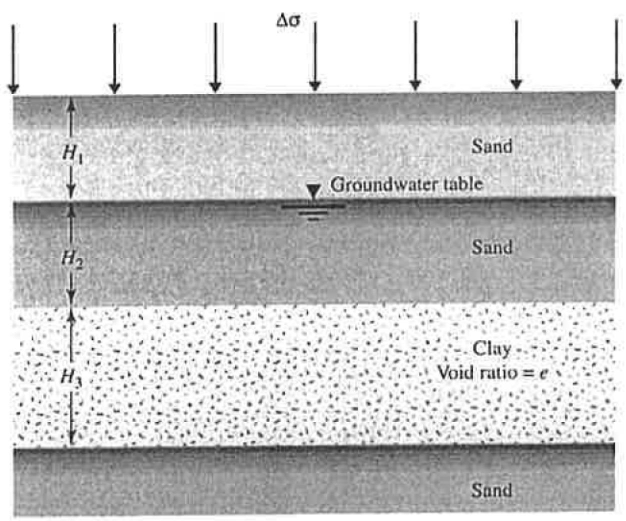
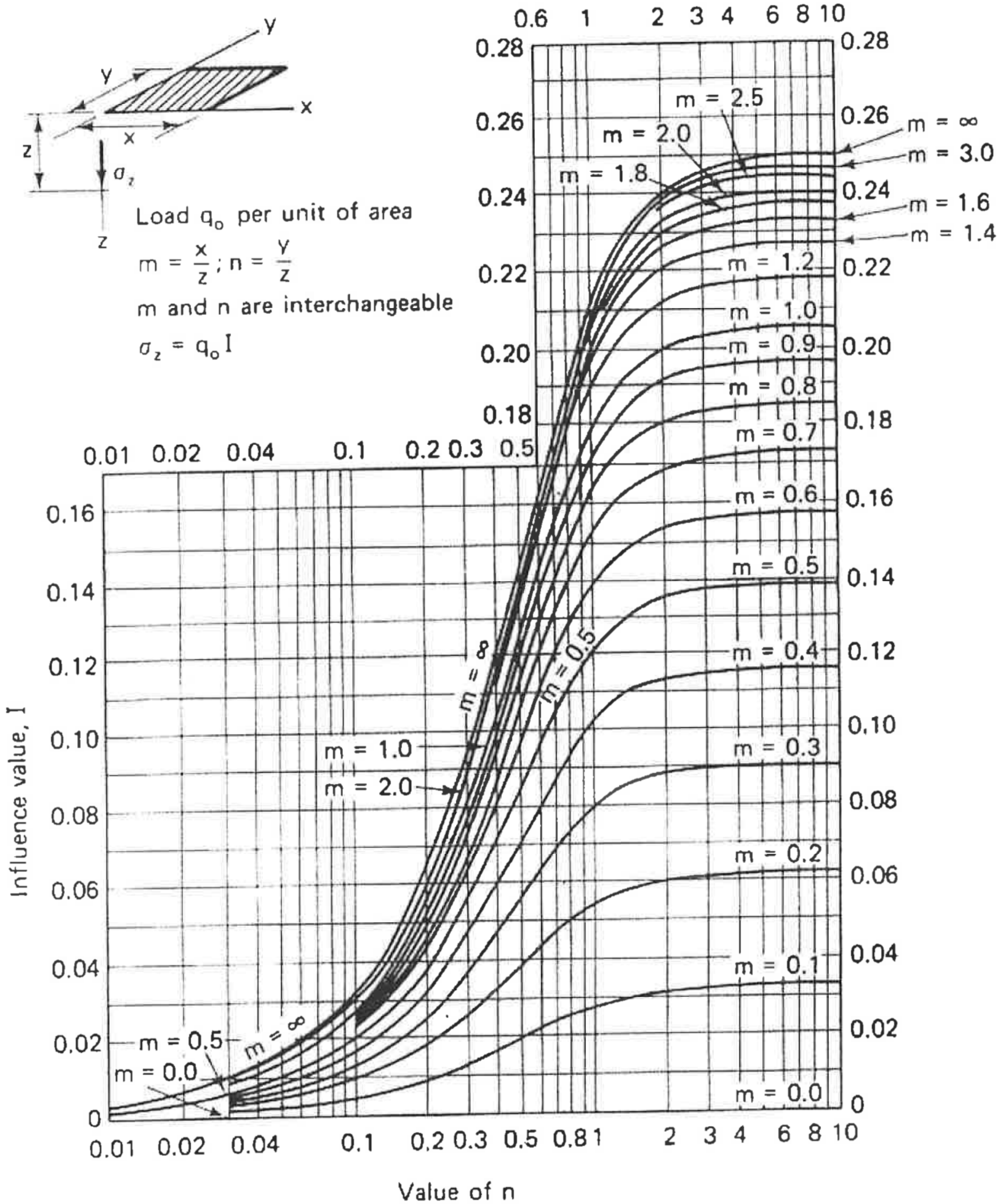
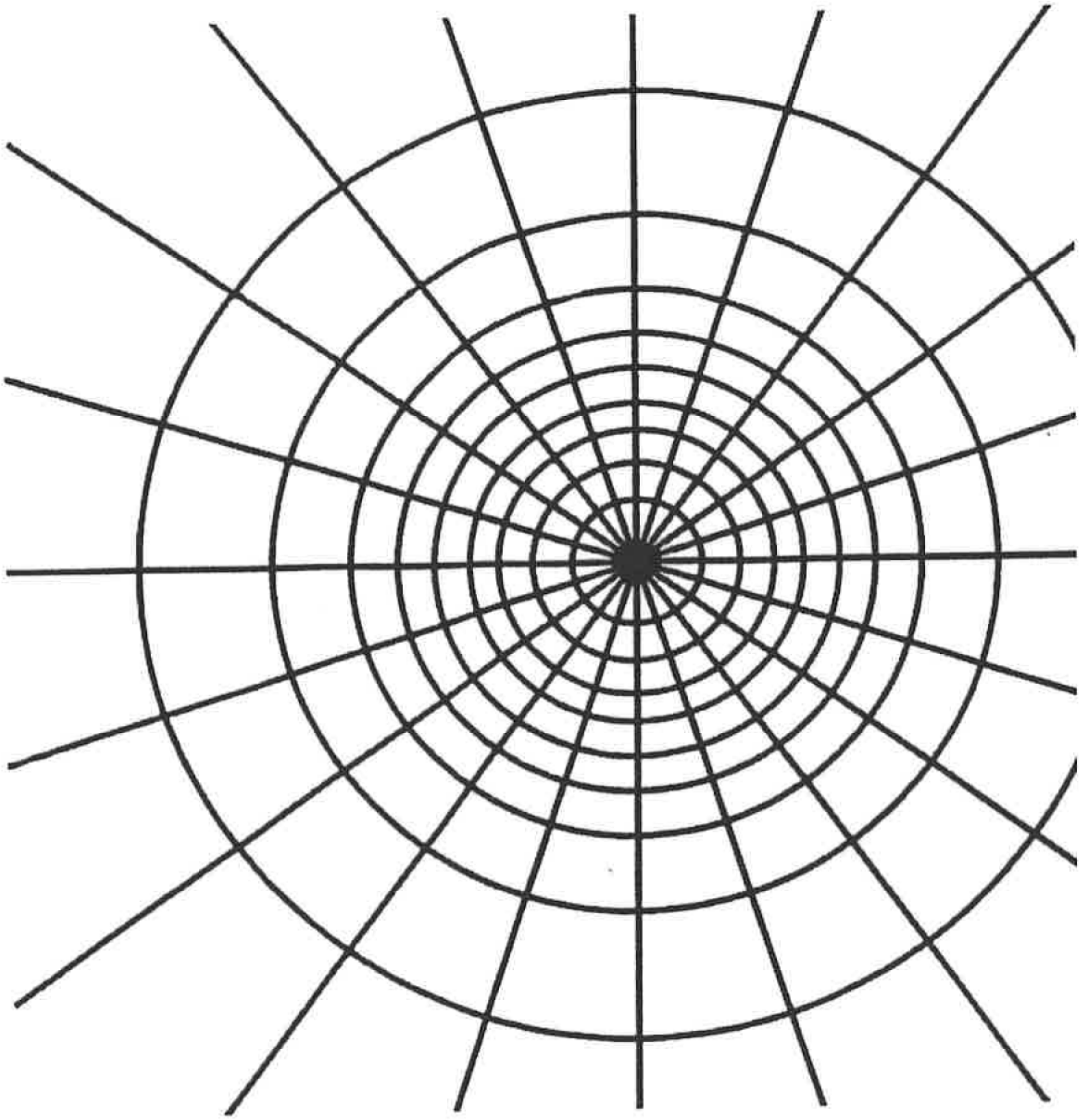


Figure 4


Load q_o per unit of area
$m = \frac{x}{z}$; $n = \frac{y}{z}$
m and n are interchangeable
$\sigma_z = q_o I$
Influence value, I
Value of n
m = ∞
m = 3.0
m = 2.5
m = 2.0
m = 1.8
m = 1.6
m = 1.4
m = 1.2
m = 1.0
m = 0.9
m = 0.8
m = 0.7
m = 0.6
m = 0.5
m = 0.4
m = 0.3
m = 0.2
m = 0.1
m = 0.0



Formula Sheet

$G_s = \frac{\rho_s}{\rho_w}$ $\rho = \frac{(Se+G_s)\rho_w}{1+e}$ $\gamma = \frac{(Se+G_s)\gamma_w}{1+e}$ $wG = Se$

$\sigma = \gamma D$

$P = \sum N' + u\,A$

$\frac{P}{A} = \frac{\sum N'}{A} + u$

$\sigma = \sigma' + u$ (or)

$\sigma' = \sigma - u$

For a fully submerged soil $\sigma' = \gamma' D$

$v = ki$; where $i = h/L$; $q = kiA$; $\Delta h = \frac{h_w}{N_d}$

$q = k \cdot h_w \cdot \frac{N_f}{N_d}(width)$; $h_p = \frac{n_d}{N_d} h_w$

Boussinesq's equation for determining vertical stress due to a point load

$$\sigma_z = \frac{3Q}{2\pi z^2}\left\{\frac{1}{1+\left(\frac{r}{z}\right)^2}\right\}^{5/2}$$

Determination of vertical stress due to a rectangular loading: $\sigma_z = q\,I_c$ (Charts also available)

$m = B/z$ *and* $n = L/z$ (both m and n are interchangeable)

Approximate method to determine vertical stress, $\sigma_z = \frac{qBL}{(B+z)(L+z)}$

Equation for determination soil vertical stress using Newmark's chart: $\sigma_z = 0.005\,N\,q$

$\tau_f = c' + (\sigma - u_w)\tan\phi'$; $\sigma_1' = \sigma_3' \tan^2\left(45^o + \frac{\phi'}{2}\right) + 2c'\tan\left(45^o + \frac{\phi'}{2}\right)$

Mohr's circles can be represented as stress points by plotting the data $\frac{1}{2}(\sigma_1' - \sigma_3')$ against $\frac{1}{2}(\sigma_1' + \sigma_3')$; $\phi' = \sin^{-1}(\tan\alpha')$ *and* $c' = \frac{a}{\cos\phi'}$

$\frac{\Delta e}{\Delta H} = \frac{1+e_o}{H_o}$; $s_c = H\frac{C_c}{1+e_o}\log\frac{\sigma_1'}{\sigma_o'}$; $s_c = \mu\, s_{od}$; $m_v = \frac{\Delta e}{1+e}\left(\frac{1}{\Delta\sigma'}\right) = \frac{1}{1+e_o}\left(\frac{e_o - e_1}{\sigma_1' - \sigma_0'}\right)$

$\frac{t_{lab}}{d_{lab}^2} = \frac{t_{field}}{(H_{field}/2)^2}$

$T_v = \frac{c_v t}{d^2}$; $T_v = \frac{\pi}{4} U^2$ (for U < 60%)

$T_v = -0.933 \log(1-U) - 0.085$ (for U > 60%)

$C_c = \frac{e_o - e_1}{\log\left(\frac{\sigma_1'}{\sigma_0}\right)}$; also, $C_c = 0.009(LL - 10)$;