PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –May 2015
Str-A3 **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.

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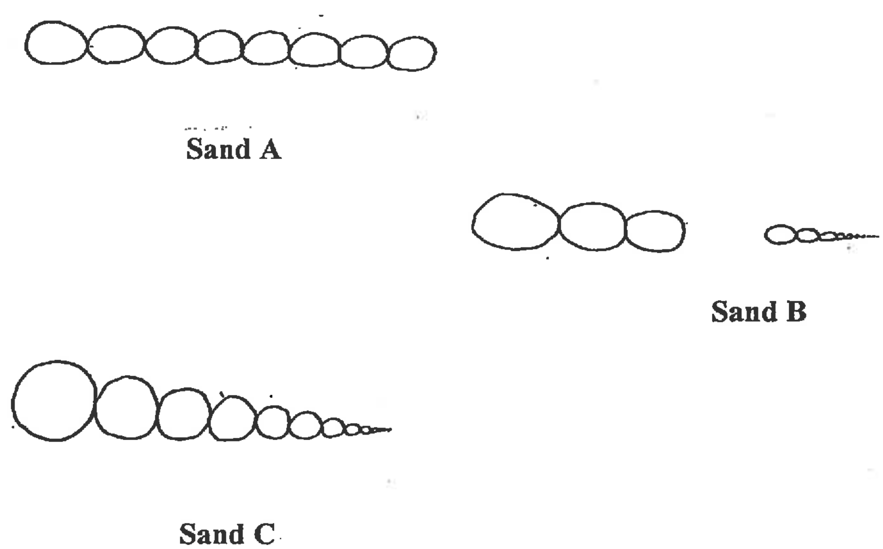
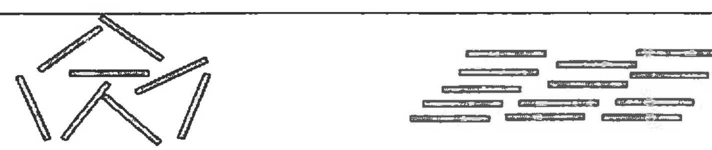
ANSWER ALL QUESTIONS

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

State the correct answer for each of the questions below and provide reasons to **JUSTIFY THE STATEMENT IN YOUR ANSWER BOOK.**

(i)	Effective stress has no physical meaning and cannot be directly measured. **True** or **False.**
(ii)	Which one of the following sandy soils (shown in **Figure 1** below); **Sand A, Sand B or Sand C** will have a higher angle of internal friction, ϕ'.  **Figure 1**
(iii)	Which one of the soils **(a)** GW, **(b)** ML or **(c)** CH will have a higher saturated coefficient of permeability?
(iv)	Which one of the following soils would have a higher compression index: **Soil A:** Normally consolidated Clay; **Soil B:** Over consolidated clay
(v)	 A) Flocculated B) Dispersed Oriented **Figure 2** A compacted fine-grained soil will typically have either a flocculated or dispersed structure as shown in **Figure 2**, based on the initial water content used for compaction. What type of soil structure will be created in fine-grained clay when it is compacted dry of optimum conditions? Give reasons.

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Question 2: **(10 marks)**

An oil tank is to be constructed on a saturated clay deposit. Oil will be filled and emptied from this tank on a regular basis at a rapid rate. What type of tests do you propose to conduct for determining the reliable shear strength parameters for design the oil tank? Also, what type of samples would you suggest be collected for conducting these tests? Give reasons.

Question 3: **(10 marks)**

One way drainage conditions prevail at a site which consists of saturated clay. The clay layer thickness of this site at location A is 10 m which settles by 40 mm in one year and corresponds to 50% of the settlement. At the same site (with identical soil properties), at location B, the clay layer thickness is 20 m. How much will the soil at location B settle for the same loading conditions?

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

A footing as shown in **Figure 3** (shaded area only) is loaded to a uniform intensity of 80 kPa.

(i) Determine the increase in vertical stress that occurs at a depth of 1.5 m below point *A* using Newmark's chart. Also, determine the increase in vertical stress using any another suitable method. Comment on the results that you have obtained using these two methods.

(ii) Will the vertical stress increase or decrease at a depth of 3.0 m for the same loading? Provide your answer as a discussion without any calculations.

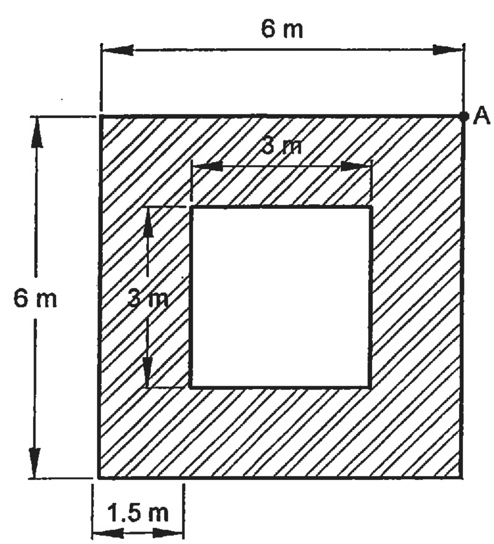

Figure 3

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

A vertical retaining wall in **Figure 4** has a height, H= 5 m . The backfill has the following properties: $H_1 = 3$m, $H_2 = 2$ m, q = 20 kN/m^3, $\gamma_1 = 18$ kN/m^3, $\phi_1 = 30°$, $c_1' = 20$ kN/m^3, $\gamma_2 = 18.5$ kN/m^3, $\phi'_2 = 25°$, and $c_2' = 25$ kN/m^3, $\gamma_{2sat} = 20$ kN/m^3. The water table is located at a depth of 4 m.

(i) Determine the Rankine active earth pressure distribution diagram behind the wall.

(ii) Estimate the Rankine active force per meter length of wall after tensile cracks appear.

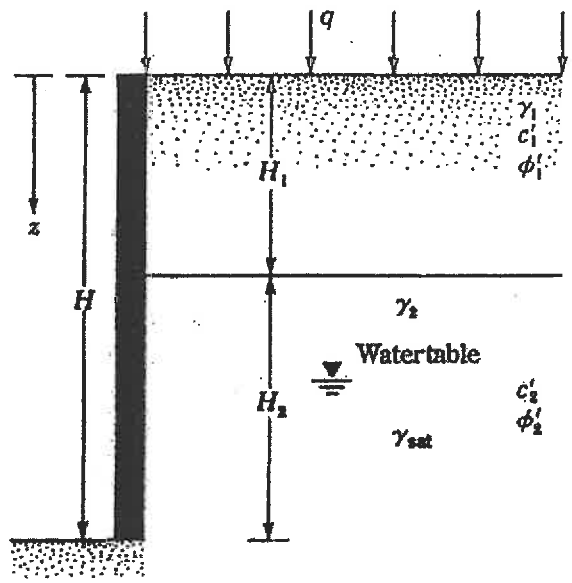

Figure 4

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

A consolidated undrained (CU) triaxial test was conducted on a clayey specimen with a confining pressure, σ_3 of 100 kPa. The deviator stress, $(\sigma_1 - \sigma_3)$ at failure condition was measured to be equal to 60 kPa. The pore-water pressure, u_w was also measured for this specimen. The shear strength parameters determined from consolidated drained (CD) triaxial tests on identical specimens of the same soil are c' = 0 kPa and $\phi' = 30°$ and from consolidated undrained (CU) triaxial tests are c = 0 kPa and $\phi = 13.3°$. Based on this information, what is the corresponding pore-water pressure that was measured in the CU test at a confining pressure of 100 kPa. What are the pore pressure coefficients A and B for the tested specimen? Is this clay normally consolidated or over-consolidated soil? Give at least three reasons to justify whether the clay is normally consolidated or over consolidated.

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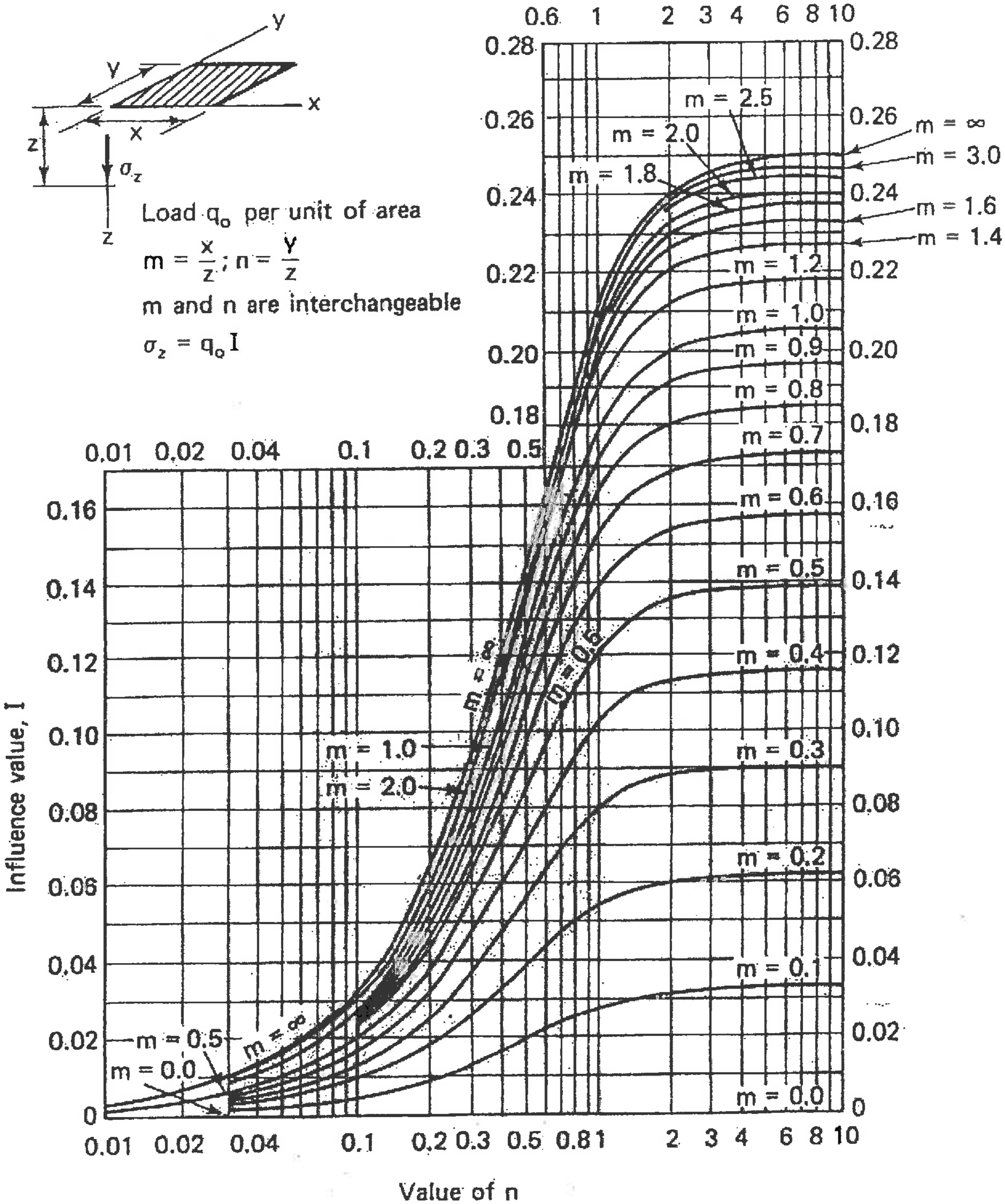

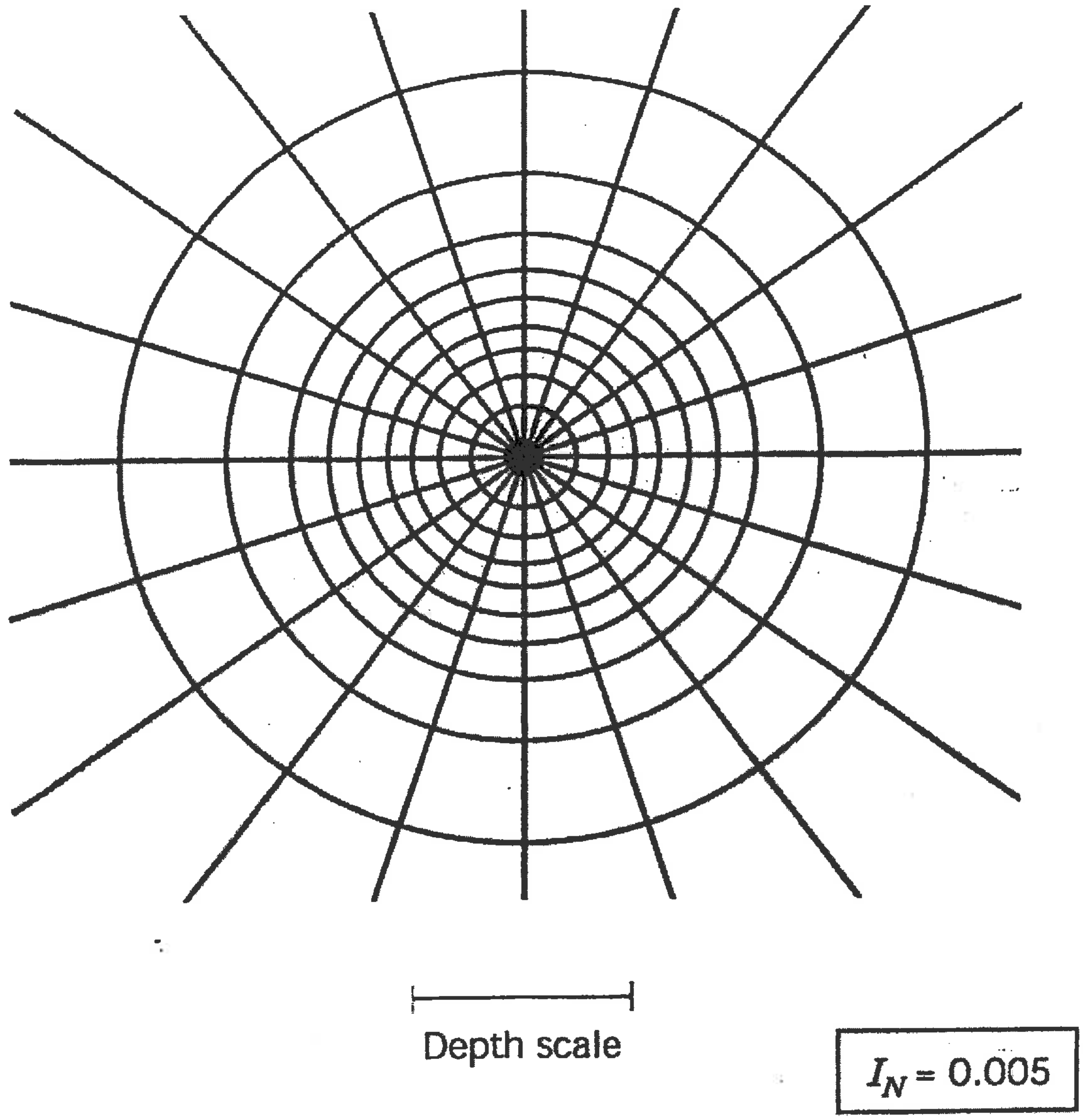
Depth scale
$I_N = 0.005$

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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 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* $c' = \frac{a}{\cos\phi'}$

$\frac{\Delta e}{\Delta H} = \frac{1+e_o}{H_o}$; $s_c = H\frac{C_c}{1+e_o}\log\frac{\sigma'_1}{\sigma_o}$; $s_c = \mu s_{od}$; $m_v = \frac{\Delta e}{1+e}\left(\frac{1}{\Delta\sigma'}\right) = \frac{1}{1+e_o}\left(\frac{e_o - e_1}{\sigma'_1 - \sigma'_0}\right)$

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

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

$$T_v = -0.933\log\left(1-U\right) - 0.085 \text{ (for U > 60\%)}$$

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