PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –May 2012
98-CIV-A4 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 to the interpretation of a question, you are encouraged to complete the question submitting a clear statement of your assumptions.
4. **You are required to answer:**
   All three questions in SECTION A ....Total 40 marks
   All three questions in SECTION B.............Total 60 marks
5. The total exam value is 100 marks
6. One of two calculators can be used: Casio or Sharp approved models.
7. Drawing instruments are required.
8. All required charts and equations are provided at the back of the examination.
9. YOU MUST RETURN ALL EXAMINATION SHEETS.

SECTION A
ANSWER ALL THREE 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.

(i)	The zero-air voids curve which is typically drawn along with the compaction curve (i.e., the relationship between the dry density and compaction water content) is typically parallel and above the compaction curve on the wet side of optimum water contents.	T	F
(ii)	The void ratio, *e*, value for some soils such as bentonite can be greater than 2.	T	F
(iii)	The stress transferred from the superstructure at a depth of 4 times the size of a square foundation in a sandy soil, is typically very low as per the theory of elasticity.	T	F
(iv)	The angle of internal friction of clayey soil (ϕ) measured from consolidated undrained conditions (without measuring the pore-water pressures) is always greater than the angle of internal friction (ϕ') for the same, measured under consolidated drained conditions.	T	F
(v)	In some organic soils, secondary compression settlement can be greater than the primary consolidation settlement.	T	F

Question 2: **(10 marks)**

Explain with neat sketches the typical response of variation of deviator stress and volume change behavior with axial strain for **loose and dense sands under drained loading conditions**. Is there any similarity in the behavior of loose and dense sands in comparison to normally consolidated and over consolidated clays?

Question 3: **(10 marks)**

With neat sketches explain the differences between **peak and critical effective friction angles**. From an engineering practice point of view, where do you recommend using these friction angles, giving reasons?

SECTION B

ANSWER **ALL THREE** QUESTIONS

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

A rectangular footing as shown in **Figure 1** (shaded area only) is loaded to an intensity of 200 kPa. Determine the increase in vertical stress that occurs at a depth of 1.5 m below the 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.

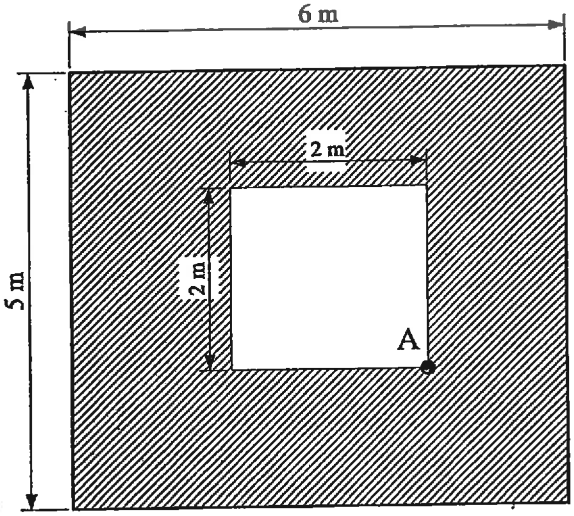


Figure 1

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

The flow net for seepage through the foundation soil below a concrete dam is shown below in Figure 2:

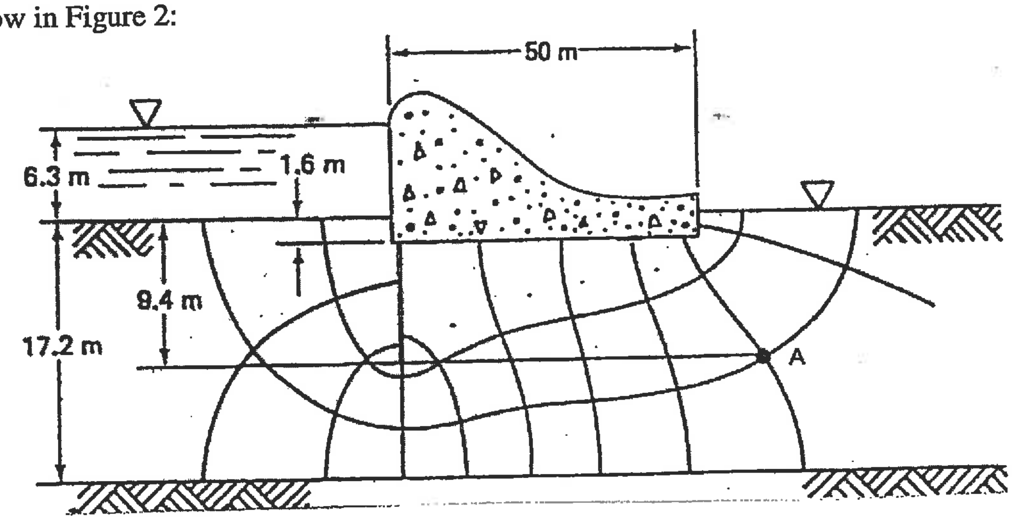


Figure 2

(i) Determine the total seepage through the foundation soil in cubic meters per day per meter of dam, if the coefficient of permeability for the foundation soil is 25×10^{-6} m/s
(ii) Calculate the effective stress at point *A* if the total unit weight of soil is 20 kN/m^3.
(iii) Calculate the maximum exit gradient.
(iv) If the exit gradient is greater than the crtical hydraulic gradient, what effect could it have on the dam?
(v) Describe two design techniques that are commonly used to decrease the magnitude of the exit gradient. Your answer should detail why they work.

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

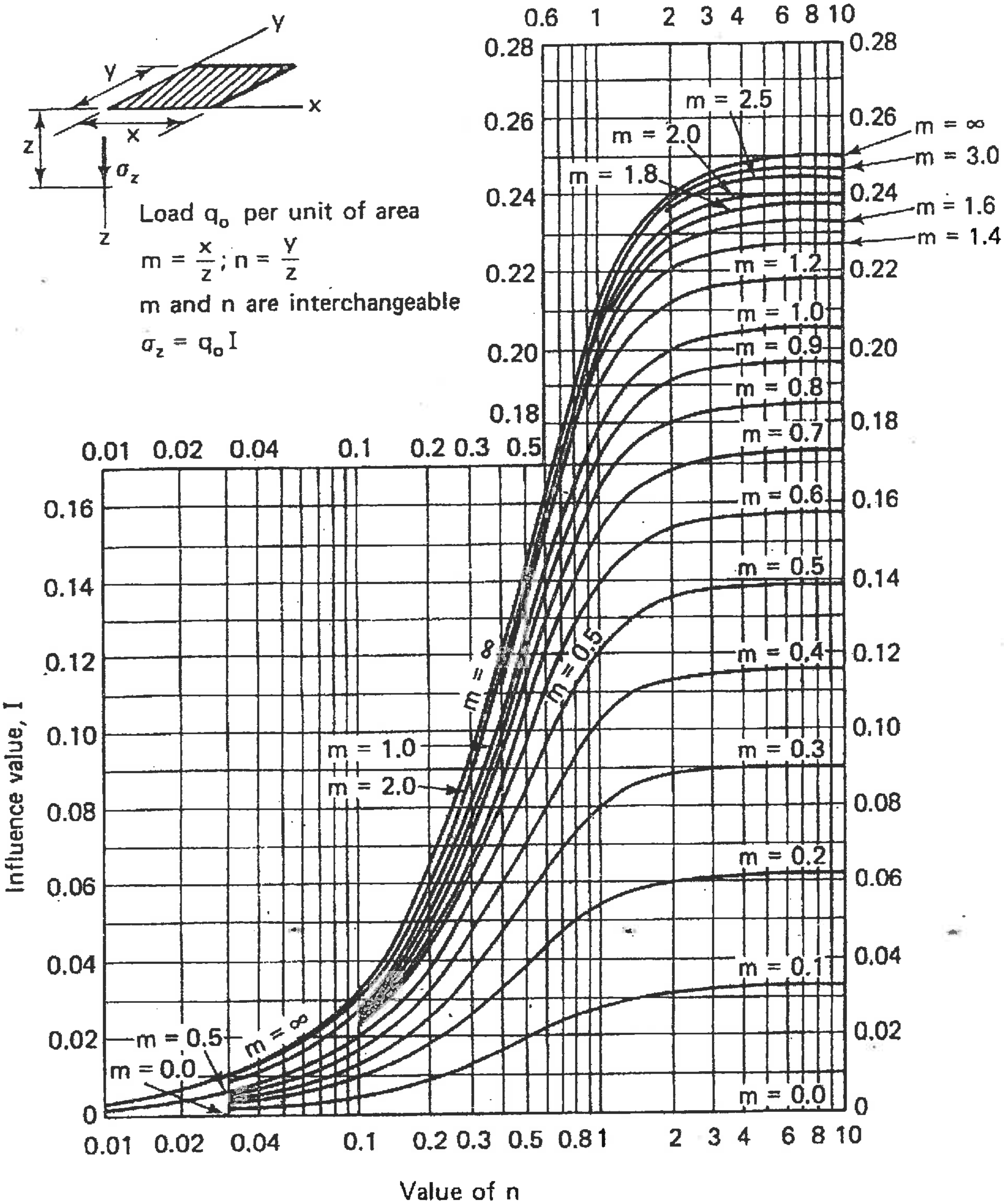
(a) The following results were obtained at failure conditions in a series of **consolidated undrained** ***(CU)*** triaxial shear strength tests with pore water pressure measurements on fully saturated clay specimens. Determine the values of the shear strength parameters ***c'*** and ϕ' by plotting a **modified failure shear strength envelope**.

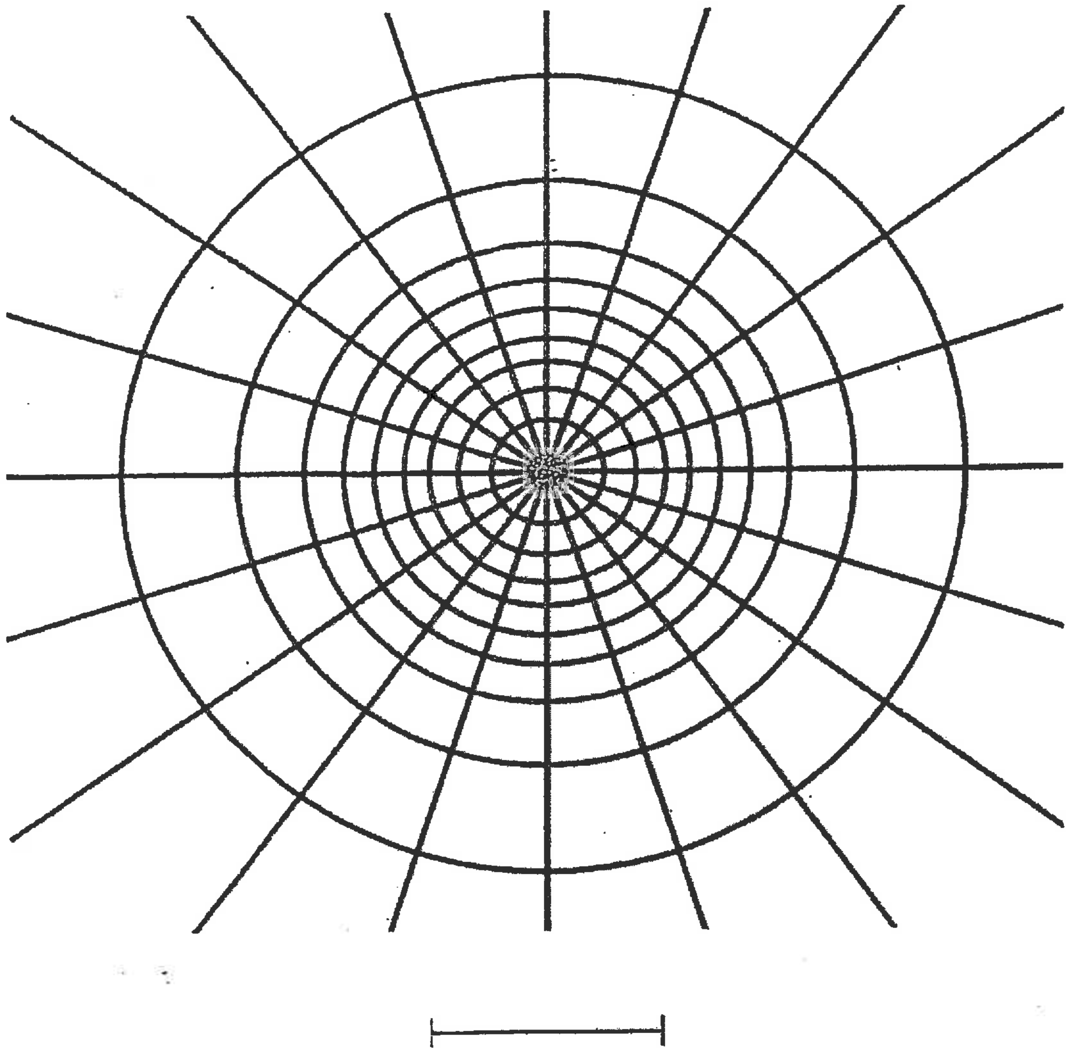
Confining pressure, σ_3 (kPa)	Deviator stress, $(\sigma_1 - \sigma_3)$ (kPa)	Pore-water pressure, u (kPa)
150	103	82
300	202	169
600	410	331

Answer the questions given below based on the results you have obtained:

(i) What is the **advantage** of plotting the **modified failure envelope** instead of **Mohr's envelope** to determine the shear strength parameters?
(ii) Is the tested clay **normally consolidated or over consolidated?** Give reasons.
(iii) If an earth dam is constructed using this clay, **can you use** the above **shear strength parameters to determine the short term or long term stability** of the structure. Give reasons.

(8+8+4 = 20 marks)


y
y
x
x
z
σ_z
z
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
m = 1.0
m = 2.0
m = 0.5
m = 0.0
m = ∞
m = ∞
m = 0.5



$I_N = 0.005$

Formula Sheet

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

$\sigma = \gamma D$

$P = \sum N' + uA$

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

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

$\sigma' = \sigma - u$

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

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

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

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: $\sigma_z = 0.005 N q$

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

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

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

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

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

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

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