NATIONAL EXAMINATIONS –DECEMBER 2017
16-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 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.

ANSWER ALL QUESTIONS

Question 1: **(10 marks)**

State the correct answer (True or False) in your ANSWER BOOK along with the Question number. Have all your answers for Question 1 at one place.

1	The angle of internal friction of normally consolidated clay determined from consolidated drained triaxial shear tests is higher in comparison to the angle of internal friction value determined from consolidated undrained tests without pore-water pressure measurements.	T	F
2	At liquid limit value the shear strength of silty clay (liquid limit = 42%) is the same as the shear strength of a clayey silt (liquid limit = 25.5%).	T	F
3	The pore-water pressure can be either negative or positive in an over consolidated clay depending on the applied normal stress.	T	F
4	The angle of internal friction of an expansive clay tested under residual conditions is lower than the peak friction value	T	F
5	The undrained cohesion value, c_u determined from an unconfined compression test on a saturated clayey sample is approximately the same as the c_u value determined from an unconsolidated undrained test.	T	F
6	Vane shear test can be used to determine the shear strength of soft saturated clays under drained loading conditions.	T	F
7	Direct shear test apparatus can be used for determining the effective shear strength parameters, c' and ϕ' of a saturated clay.	T	F
8	The strength parameters have to be determined under consolidated drained loading conditions to estimate the long term stability of a homogenous earth dam constructed using homogeneous clay.	T	F
9	Sand typically liquefies when the hydraulic gradient reaches critical condition.	T	F
10.	A well graded sand has a lower angle of friction value compared to a gap graded soil	T	F

Question 2: **(10 marks)**

Draw the horizontal distribution of **relative** vertical stress, σ_z , due to a point load Q at depths of 0.1 m, 1m, 2m, 3m and 5m. Also, draw the horizontal distribution of **relative** horizontal stress at depths of 1 m and 5m. Explain the reasons for this behavior.
***Please note that you don't have to calculate ANY specific values.* Only draw figures.**

Question 3: **(Value: 20 marks)**

A footing as shown in **Figure 3** (shaded area only) is loaded to a uniform intensity of 100 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.

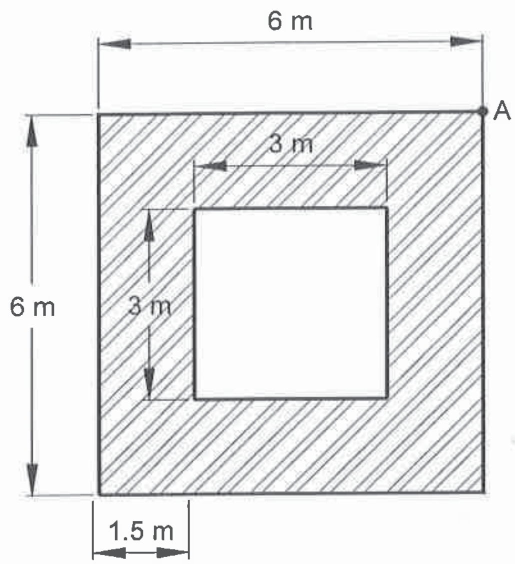


Figure 3

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

The following results were obtained from an oedometer test (i.e., consolidation test) on a specimen of saturated clay:

Pressure (kN/m²)	27	54	107	214	429	214	107	54
Void ratio	1.243	1.217	1.144	1.068	0.994	1.001	1.012	1.024

A layer of this clay 8m thick lies below a 4m depth of sand, the water table being at the surface. The saturated unit weight for both soils is 19 kN/m^3. A 4m depth of fill of unit weight 20 kN/m^3 is placed on the sand over an extensive area.

a. Determine the settlement due to consolidation of the clay.

b. If the fill was removed some time after the completion of consolidation, calculate the heave or consolidation that would eventually take place due to swelling of the clay?

Question 5: **(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 ϕ' = 30° and from consolidated undrained (CU) triaxial tests are c = 0 kPa and ϕ = 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? Give at least three reasons to justify whether the clay is normally consolidated or over consolidated.

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

The flow net for seepage through the foundation soil under a concrete dam is shown below in **Figure 4**.

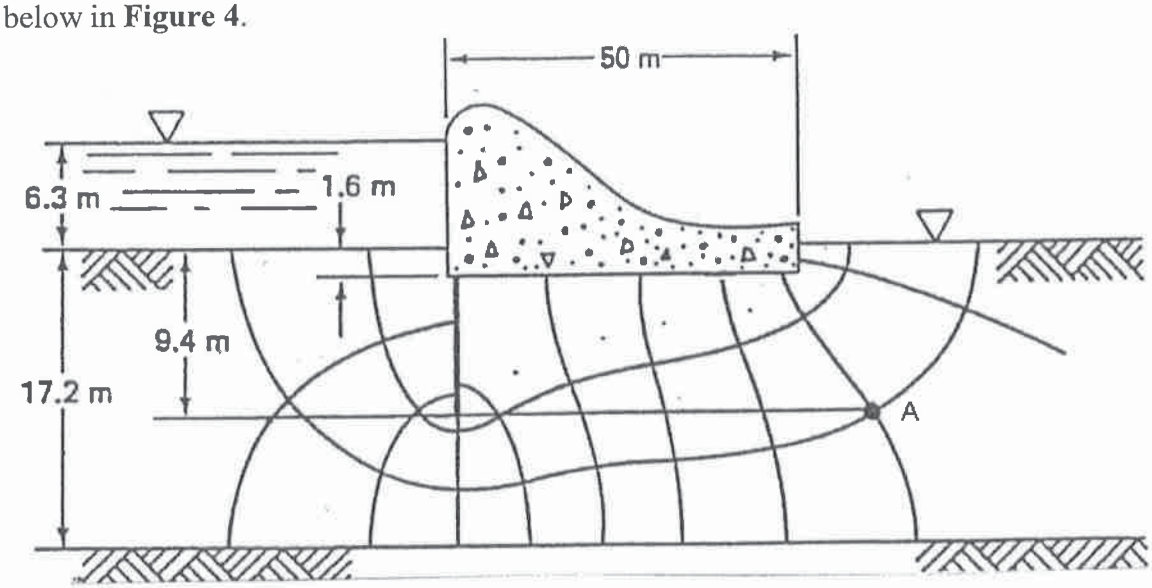
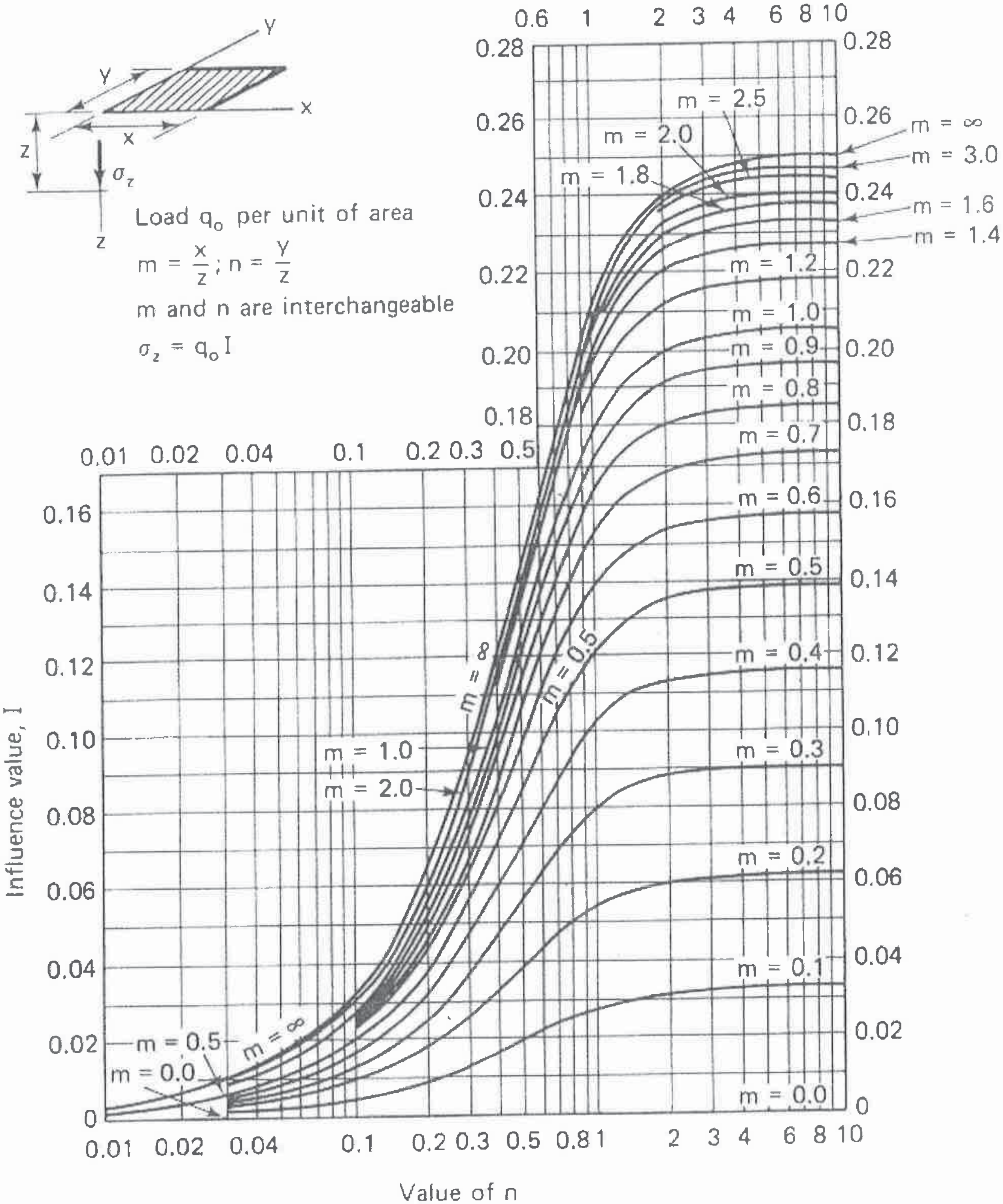


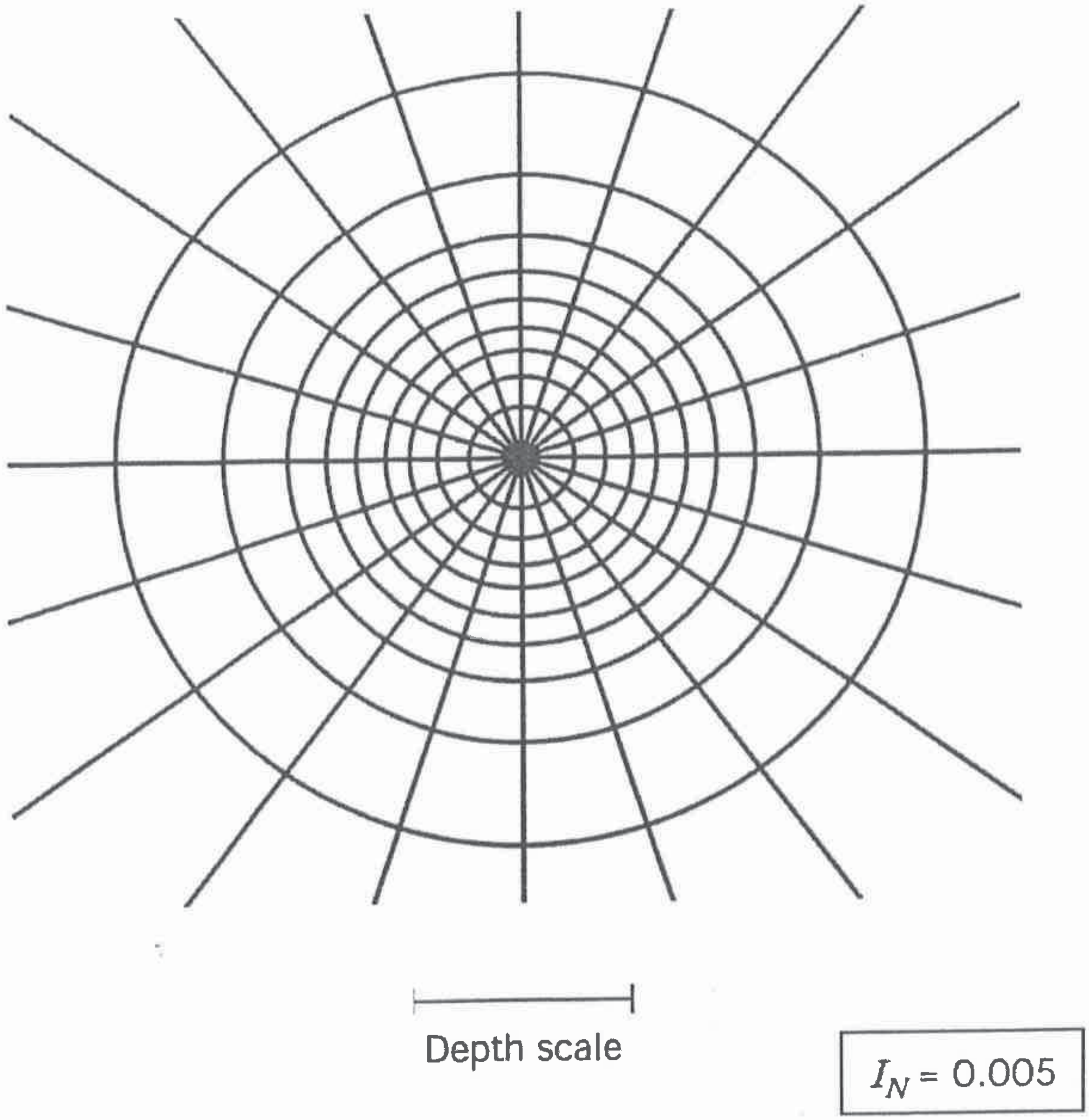
Figure 4

(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 x 10^{-6} m/s

(ii) Calculate the effective stress at point *A* if the total unit weight of the soil is 19 kN/m^3.

(iii) Calculate the maximum exit gradient. If this gradient is assumed to be greater than the crtical hydraulic gradient, what effect could it have on the dam?


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
$\sigma_z = q_o I$
m = 2.5
m = 2.0
m = 1.8
m = ∞
m = 3.0
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 = ∞
m = 0.5
m = 1.0
m = 2.0
m = 0.5
m = 0.0
m = ∞
Influence value, I
Value of n


Depth scale
I_N = 0.005

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

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

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

$T_v = \frac{c_v t}{d^2}$; $T_v = \frac{\pi}{4}U^2$ (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, $C_c = 0.009(LL - 10)$;