

PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –May 2014
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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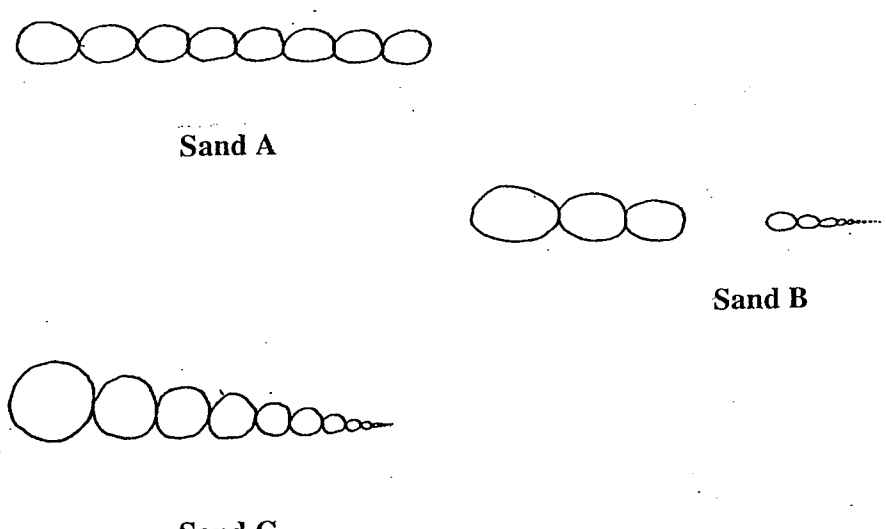
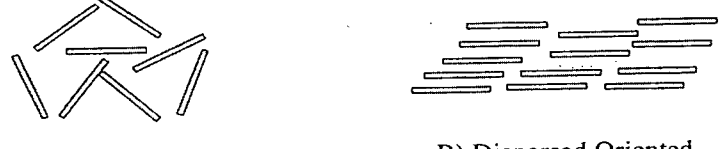
NATIONAL EXAMINATIONS –May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

ANSWER ALL QUESTIONS

Question 1:

(4 x 5 = 20 marks)

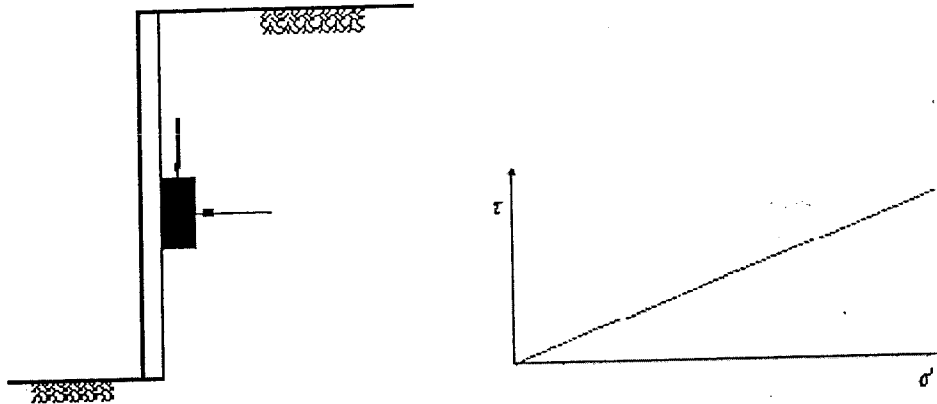
State the correct answer for each of the questions below and provide reasons to **JUSTIFY THE STATEMENT IN YOUR ANSWER BOOK.**

(i)	Which one of the following sandy soils; Sand A with coefficient of uniformity, $C_u = 4$ or Sand B with $C_u = 1$ would have a greater shear strength.
(ii)	<p>Which one of the following sandy soils (shown in Figure 1 below); Sand A, Sand B or Sand C will have a lower coefficient of permeability.</p>  <p align="center">Figure 1</p>
(iii)	Which one of the soils GW, ML or CH will have a higher dry density and also a higher optimum moisture content?
(iv)	Which one of the following soils would have a higher effective angle of internal friction (ϕ') determined from consolidated drained triaxial shear tests: Soil A: Expansive clay; Soil B: Glacial till; Soil C: Silt; Soil D: Sand
(v)	 <p align="center">Figure 2</p> <p>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 wet of optimum conditions?</p>

NATIONAL EXAMINATIONS – May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

Question 2:**(10 marks)**

Briefly explain the three different “limit” lateral earth pressures (i.e., at-rest, active, and passive conditions) that can act on a retaining wall. Also, show the Mohr circle for each condition (Note: You are expected to draw simple sketches of retaining walls and Mohr failure envelopes for the three cases; **Figure 3** is shown below as an example without providing the key details).

**Figure 3****Question 3:****(10 marks)**

Laboratory tests on a 40-mm-thick clay specimen drained at the top only shows that 50% consolidation takes place in 18 min.

- (i) How long will it take for a layer of the same clay in the field, 4 m thick and drained at the top and bottom, to undergo 50 % consolidation?
- (ii) Find the time required for the clay layer in the field, as described in part (i), to reach 80 % consolidation.

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

A footing as shown in **Figure 4** (shaded area only) is loaded to a uniform intensity of 100 kPa. Determine the increase in vertical stress that occurs at a depth of 2.0 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.

NATIONAL EXAMINATIONS – May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

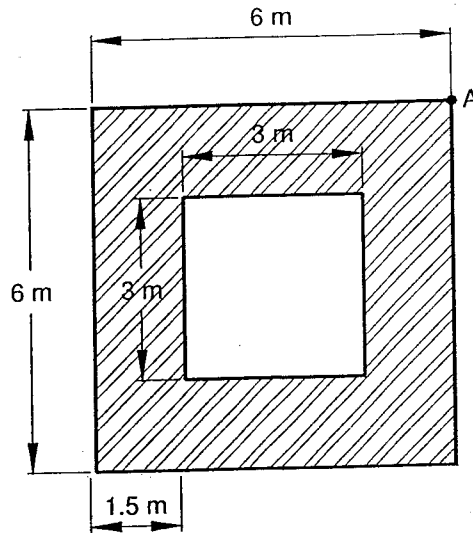


Figure 4

(Value: 20 marks)

Question 5:

A dam, shown in **Figure 5** retains 10 m of water. A sheet pile wall (cutoff curtain) on the upstream side, which is used to reduce seepage under the dam, penetrates 7 m into a 20 m thick silty sand stratum. Below the silty sand is a thick deposit of clay. The average coefficient of permeability of the silty sand is 2.0×10^{-4} cm/sec. Assume that the silty sand is homogeneous and isotropic.

- (i) Draw the **flow net** under the dam.
- (ii) Calculate the **seepage rate, q** per meter length of the sheet pile.

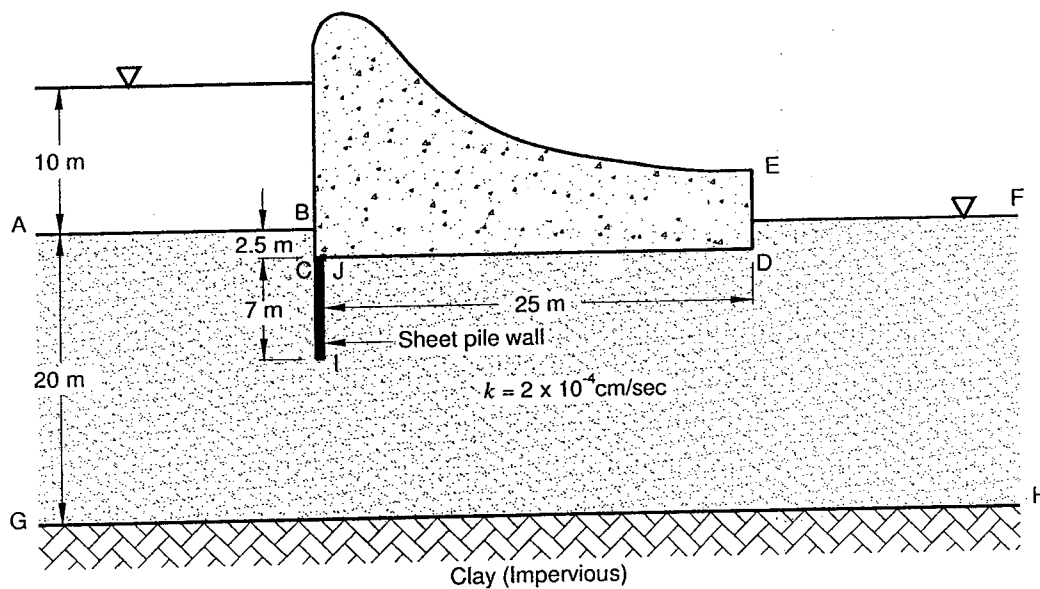


Figure 5

NATIONAL EXAMINATIONS –May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

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 envelope**.

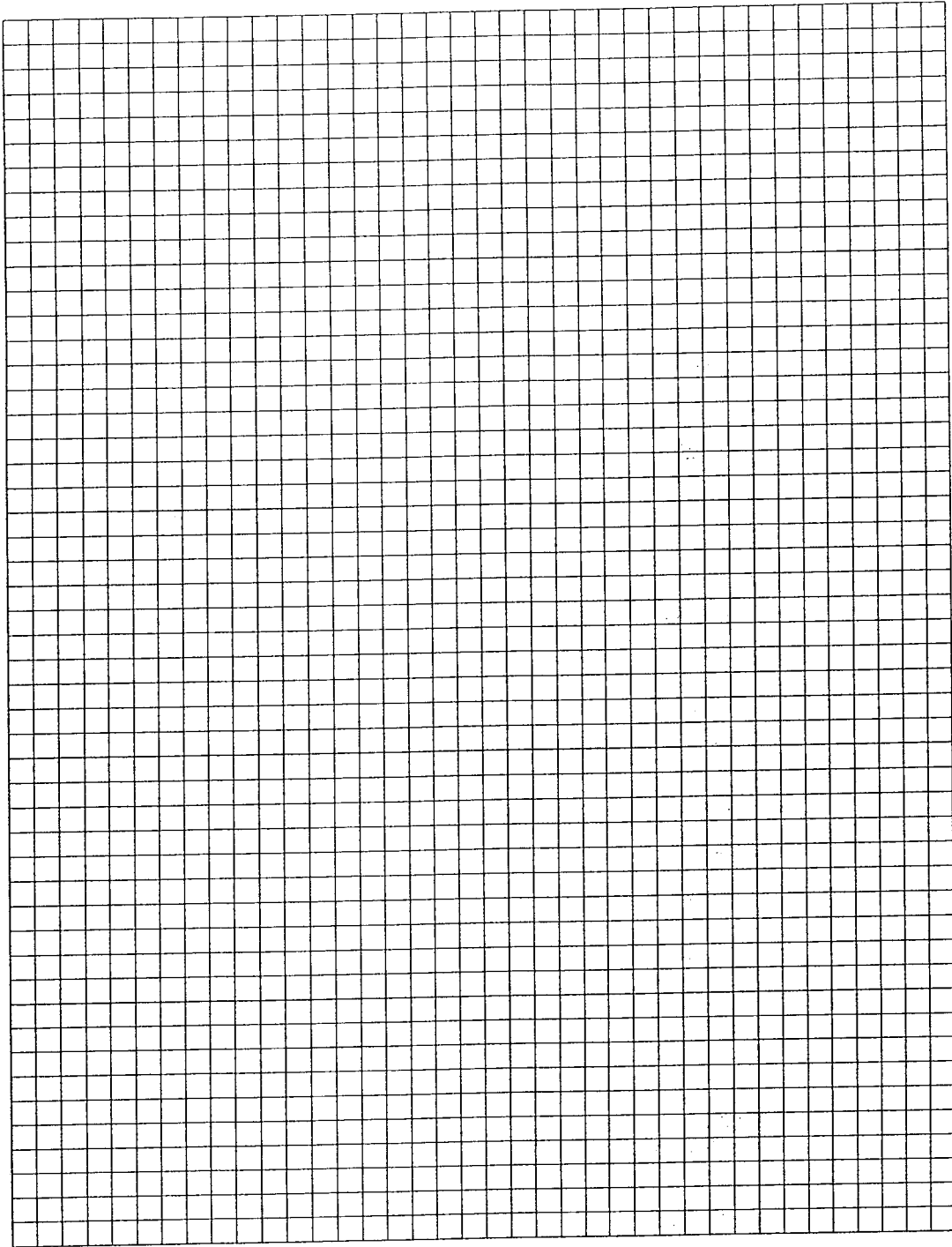
Confining pressure, σ_3 (kPa)	Deviator stress, $(\sigma_1 - \sigma_3)$ (kPa)	Pore-water pressure, u (kPa)
150	100	80
300	200	160
600	400	320

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

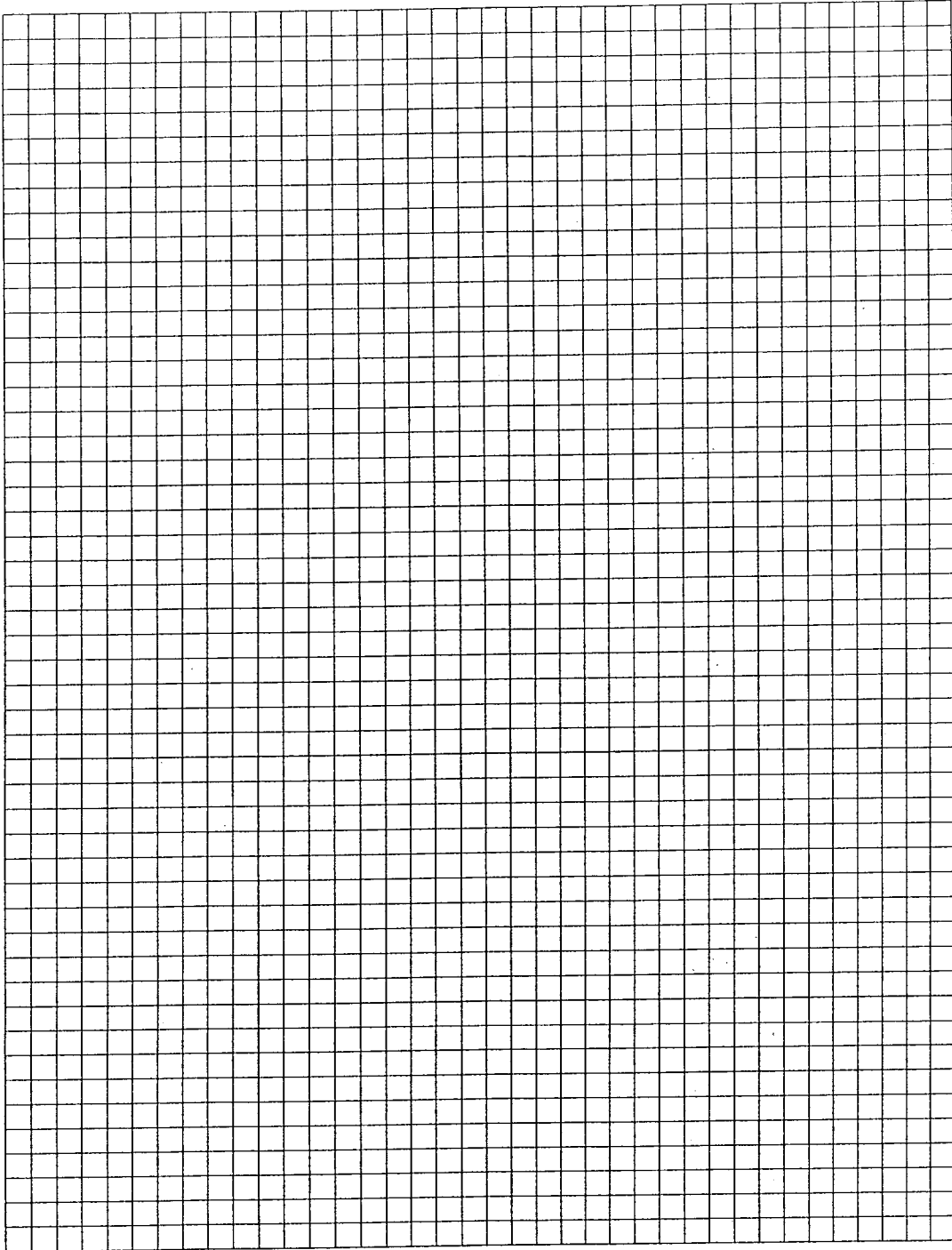
- (i) What is the **advantage** of plotting the **modified failure envelope** instead of **Mohr's envelope** to determine the shear strength parameters?
- (ii) Is the tested clay **normally consolidated or over consolidated**? Give reasons.
- (iii) If an earth dam is constructed using this clay, can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

(8+8+4 = 20 marks)

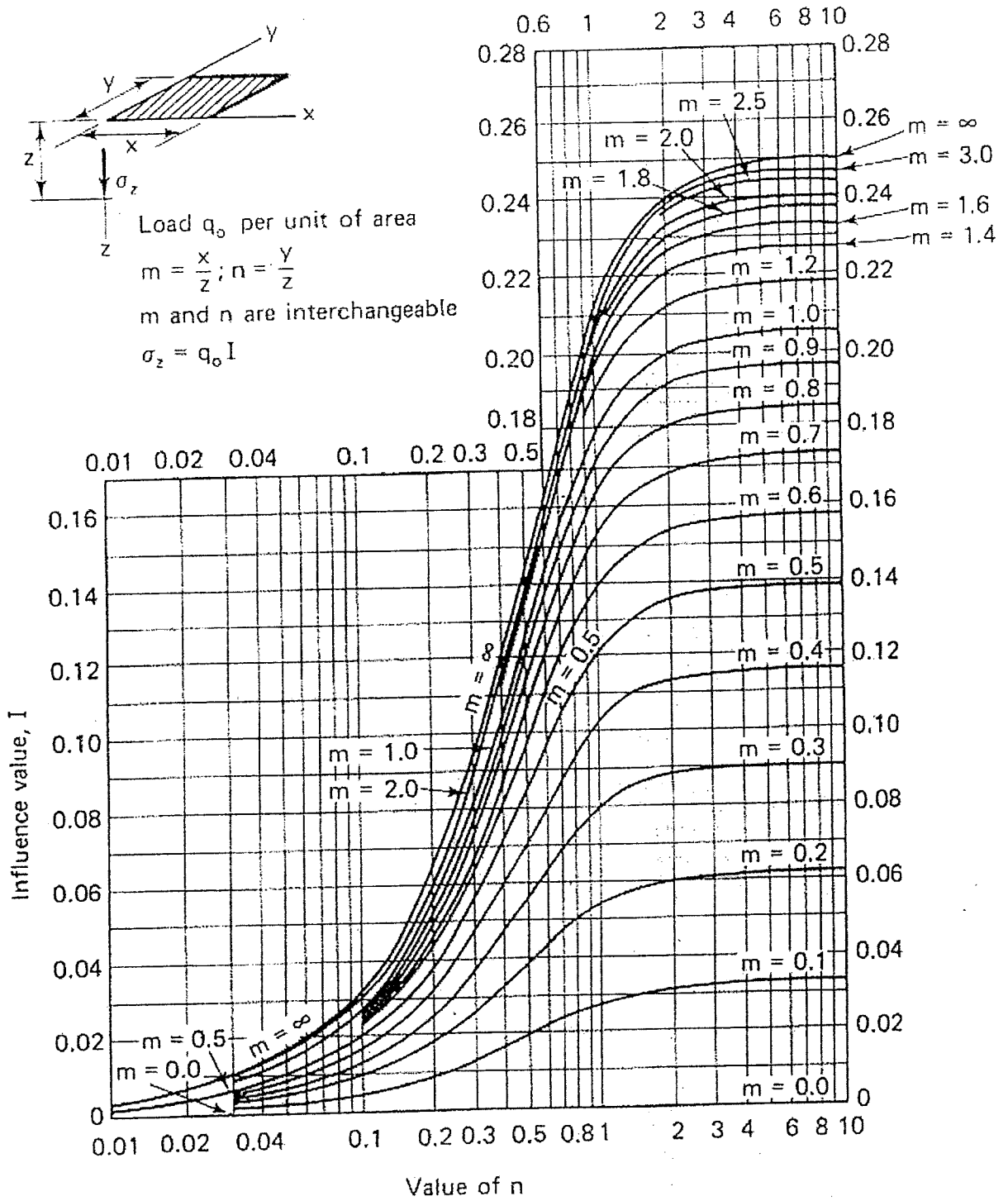
NATIONAL EXAMINATIONS -May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS



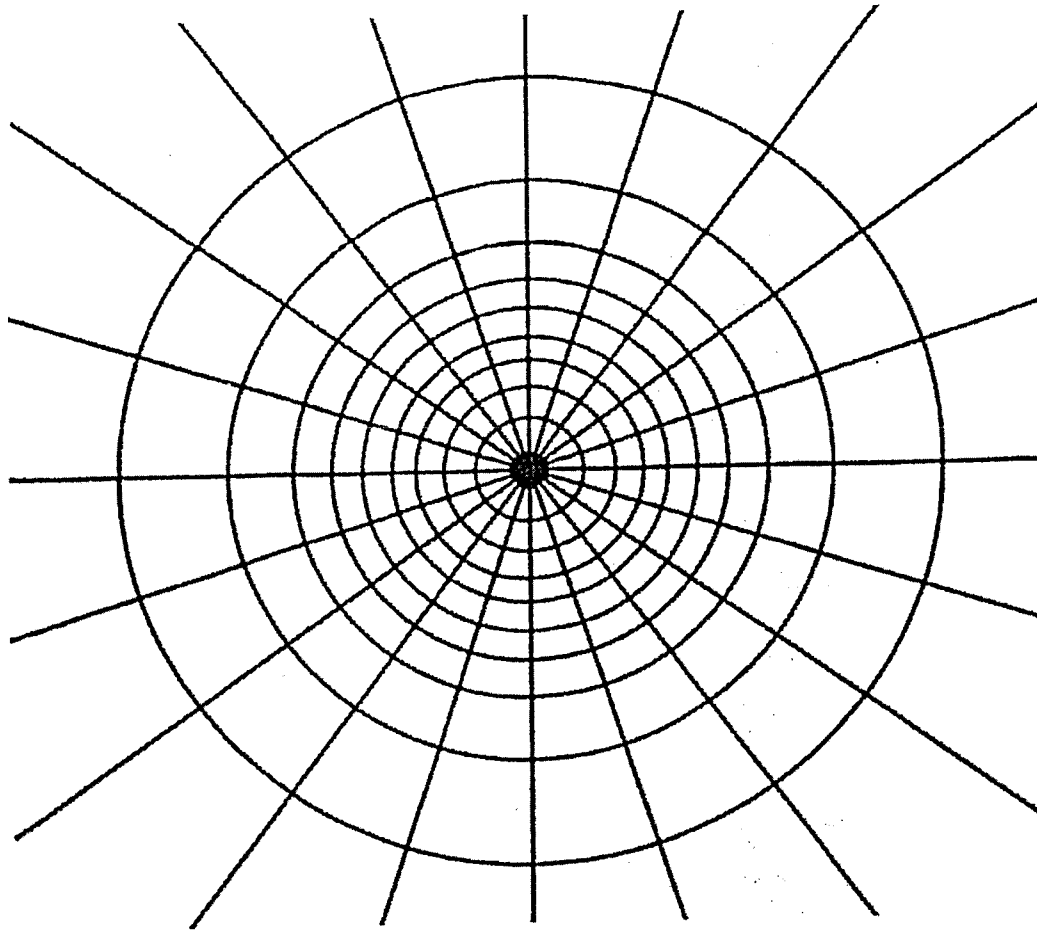
NATIONAL EXAMINATIONS - May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS



NATIONAL EXAMINATIONS – May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS



NATIONAL EXAMINATIONS - May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS



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Depth scale

$I_N = 0.005$

NATIONAL EXAMINATIONS – May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

Formula Sheet

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

$$\sigma = \gamma D$$

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

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

$$\sigma = \sigma' + u \text{ (or)}$$

$$\sigma' = \sigma - u$$

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

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

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

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: $\sigma_z = 0.005 N q$

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

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

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

NATIONAL EXAMINATIONS – May 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

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

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

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

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