

**PROFESSIONAL ENGINEERS ONTARIO**  
**NATIONAL EXAMINATIONS –December 2012**  
**98-CIV-A4 GEOTECHNICAL MATERIALS AND ANALYSIS**

**3 HOURS DURATION**

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- 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 four questions in SECTION A .....Total 40 marks**  
**Three out of four questions SECTION B....Total 60 marks**
  5. The total exam value is 100 marks
  6. For Section A answer all questions
  7. For Section B only the first three questions answered will be graded.
  8. One of two calculators can be used: Casio or Sharp approved models.
  9. Drawing instruments are required.
  10. All required charts and equations are provided at the back of the examination.
  11. **YOUR MUST RETURN ALL EXAMINATION SHEETS.**
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**SECTION A**  
**ANSWER ALL FOUR QUESTIONS**

**Question 1:**

**(Value: 4 x 5 = 20 marks)**

State the correct answer and justify the statement in your answer book.

(i)	The coefficient of permeability of uniform sand is lower than well graded sand.	T	F
(ii)	The soil at a depth of 2 m will be subjected to higher stress due to the load associated with the construction of 10 residential storey structure (i.e., 30 m high) compared to 10 m high earthen embankment.	T	F
(iii)	The degree of saturation of a compacted specimen at wet of optimum water content is always lower than 100%.	T	F
(iv)	The pore-water pressures are likely to be negative in typical overconsolidated clay samples when they are subjected to shear loading in a triaxial test apparatus with a confining pressure lower than their pre-consolidation pressure.	T	F
(vi)	The direct shear test apparatus can be used for reliably determining the shear strength parameters of sand under unconsolidated and undrained conditions (i.e., UU).	T	F

**Question 2:**

**(Value: 10 marks)**

Figure 1 shows an impermeable upstream blanket that can be used to partially reduce seepage below an embankment. Explain the principle of this seepage control method.

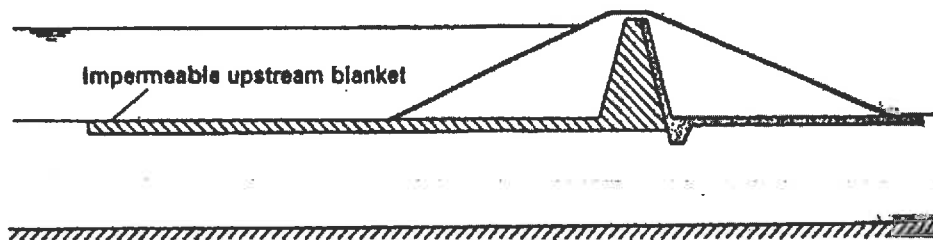


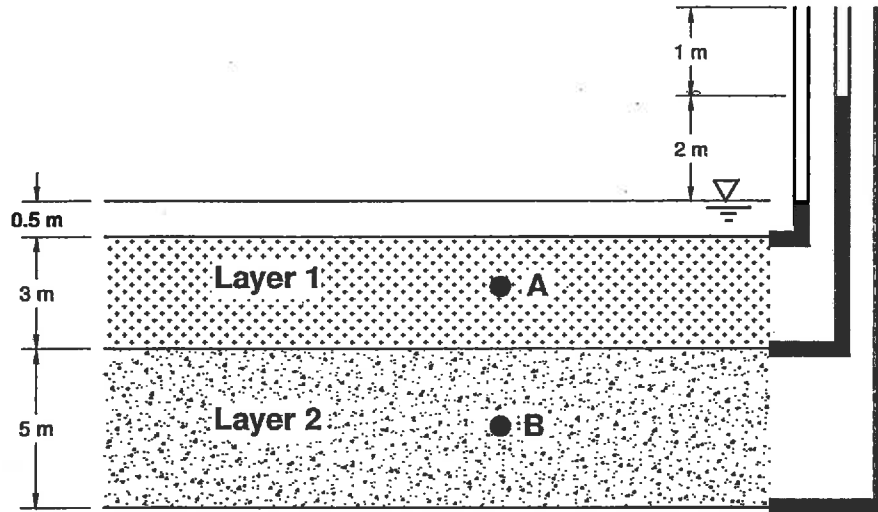
Figure 1.

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**Question 3:**

**(Value: 10 marks)**

Calculate the i) total stress, ii) pore-water pressure, and iii) effective stress at the mid depth of each layer (i.e. points A and B) shown in Figure 2, given  $\gamma_{\text{sat}(A)} = 18.5 \text{ kN/m}^3$  and  $\gamma_{\text{sat}(B)} = 20 \text{ kN/m}^3$ .



**Figure 2**

**SECTION B**

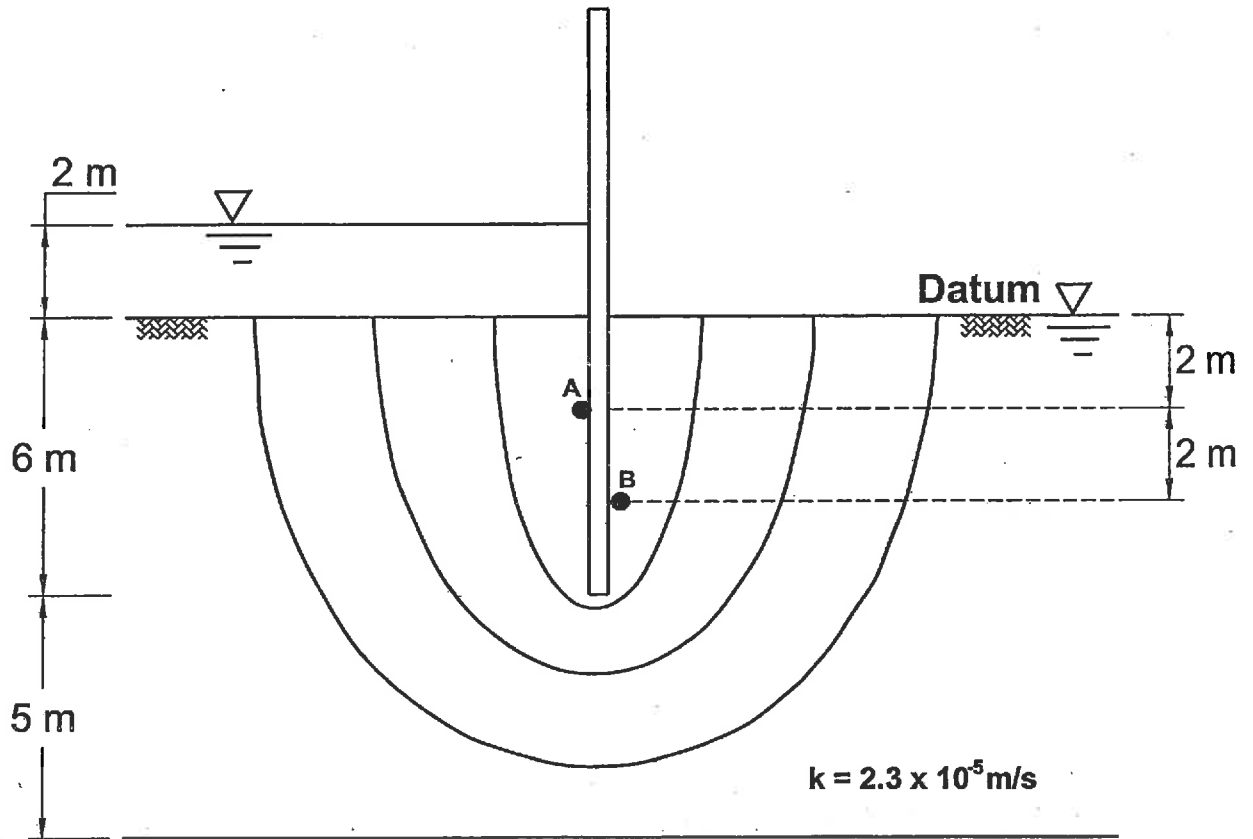
**ANSWER ANY THREE OF THE FOLLOWING  
FOUR QUESTIONS**

**Question 4:**

**(Value: 20 marks)**

The flow lines for a thin cutoff wall are shown in Figure 3

- (i) Complete the flownet by drawing equipotential lines (Follow all the rules in drawing the flownet).
- (ii) Determine the quantity of seepage ( $\text{m}^3/\text{s}$  per m) (coefficient of permeability,  $k = 2.3 \times 10^{-5} \text{ m/s}$ ).
- (iii) Calculate the effective stress at points A (back of the piling) and B (front of the piling) ( $\gamma_{\text{sat}} = 20 \text{ kN/m}^3$ ).



**Figure 3**

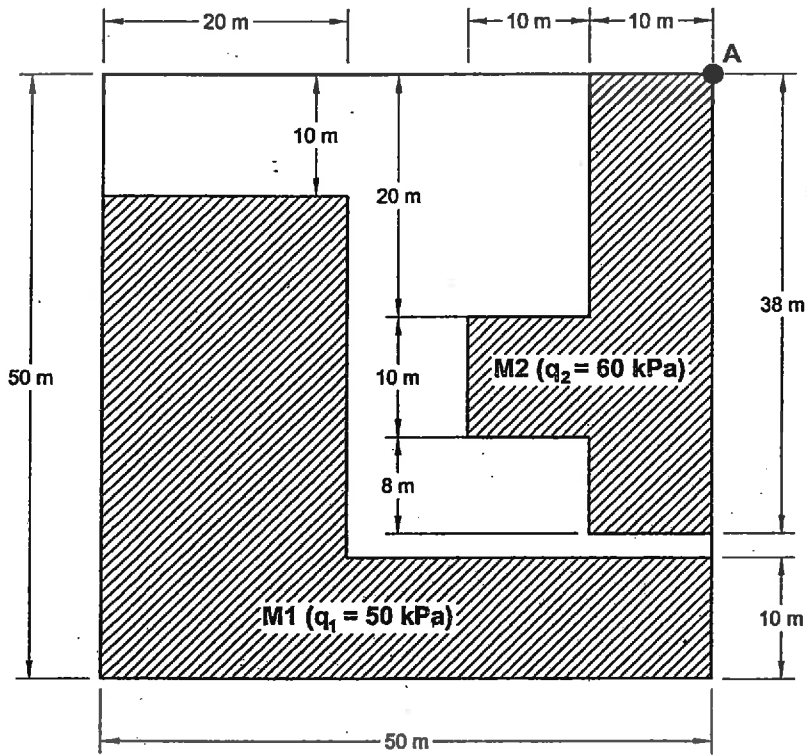
**Question 5:**

**(Value: 20 marks)**

Figure 4 shows the plan view of two multiplex buildings, M1 and M2. The foundations of M1 and M2 are loaded with a uniform stress of 50 kPa ( $q_1$ ) and 60 kPa ( $q_2$ ), respectively. Determine the increase in vertical stress  $\Delta\sigma_z$  due to  $q_1$  and  $q_2$  at the depth of 25 m vertically below point A (Use superposition method).

- Use  $m$  and  $n$  coefficients for estimating  $\Delta\sigma_{z1}$  due to  $q_1$ .
- Use Newmark chart for estimating  $\Delta\sigma_{z2}$  due to  $q_2$ .

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**Figure 4**

**Question 6:**

**(Value: 20 marks)**

A series of consolidated drained triaxial tests was carried out on specimens of a sand prepared at the same porosity and the following results were obtained at failure.

All-round (cell) pressure (kN/m <sup>2</sup> )	100	200	400	800
Principal stress difference (kN/m <sup>2</sup> )	452	908	1810	3624

Determine the value of the angle of shearing resistance  $\phi'$  analytically and also draw the Mohr circles to verify your result graphically. Comment on the expected pore-water pressure while conducting the tests at different all round pressures of 100, 200, 400 and 800 kPa.

**Question 7:**

**(Value: 20 marks)**

Determine the consolidation settlement of the footing shown in Figure 5: Given that  $B = 1.5$  m,  $L = 2.5$  m, and  $Q = 100$  kN. Provide details of any two other methods that can be used for determining the consolidation settlement for the same problem. What additional data is necessary for the two methods you suggest.

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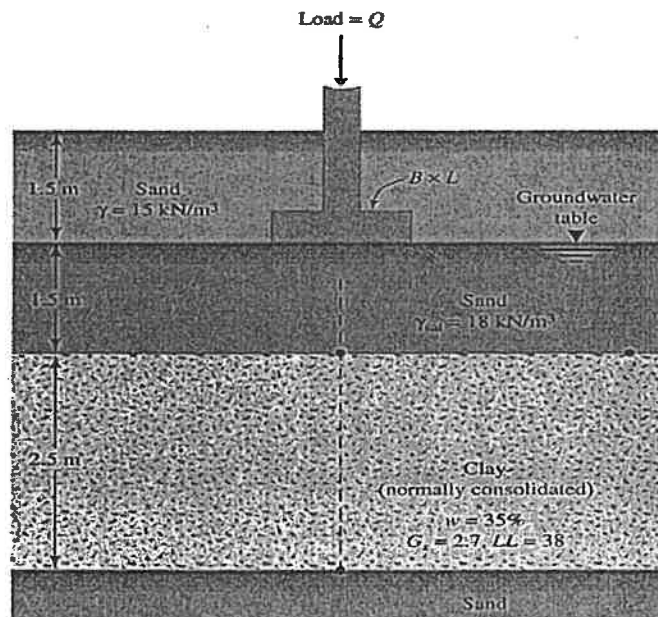
**Note:** Use  $\Delta\sigma'_{av} = \frac{\Delta\sigma'_t + 4\sigma'_m + \Delta\sigma'_b}{6}$  for determining the average increase in the clay layer

where:  $\Delta\sigma'_t$  = effective stress increase at the top of clay layer

$\Delta\sigma'_m$  = effective stress increase at the middle of clay layer

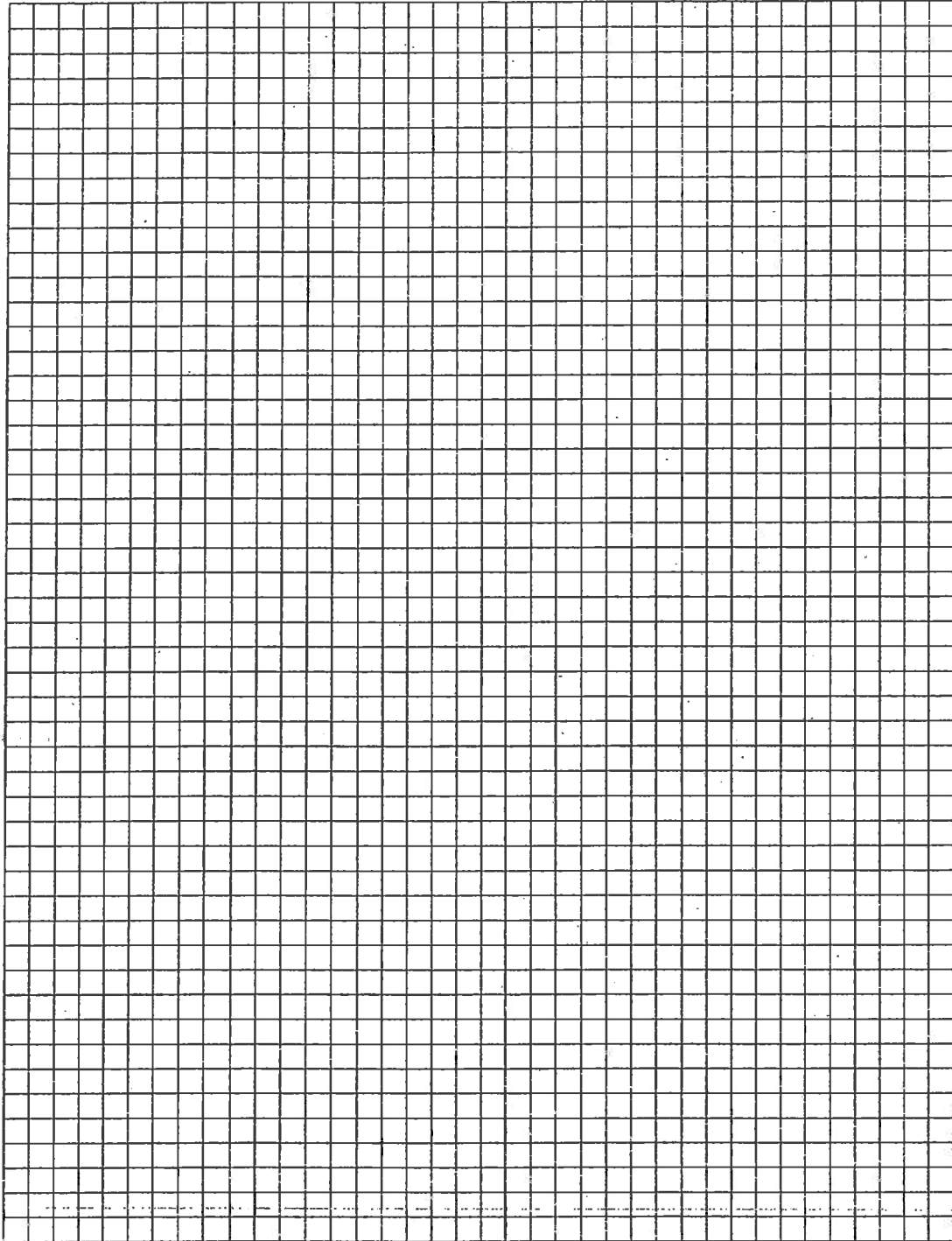
$\Delta\sigma'_b$  = effective stress increase at bottom of clay layer

Use any suitable method for finding the increase in stress  $\Delta\sigma'$ .

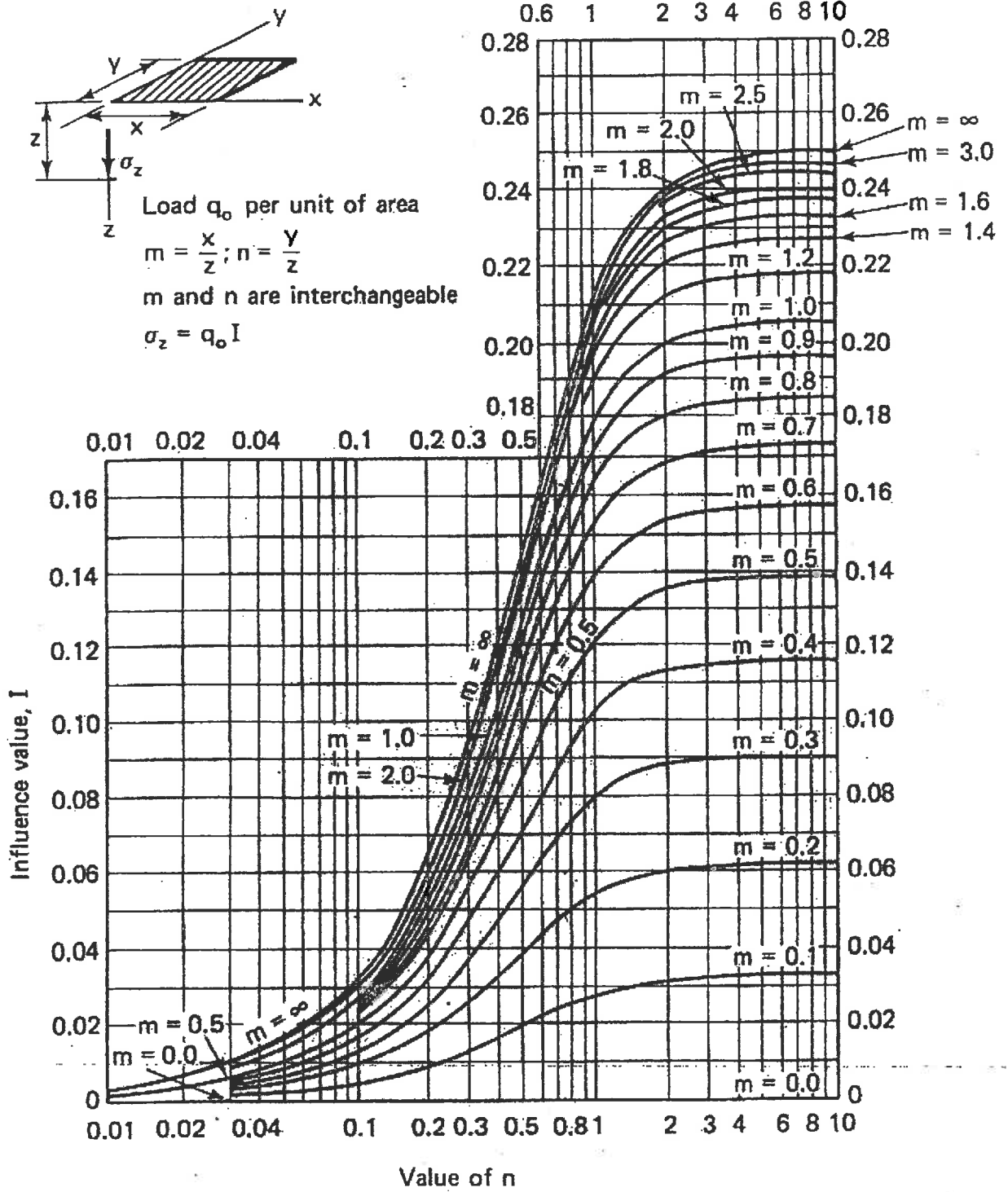


**Figure 5**

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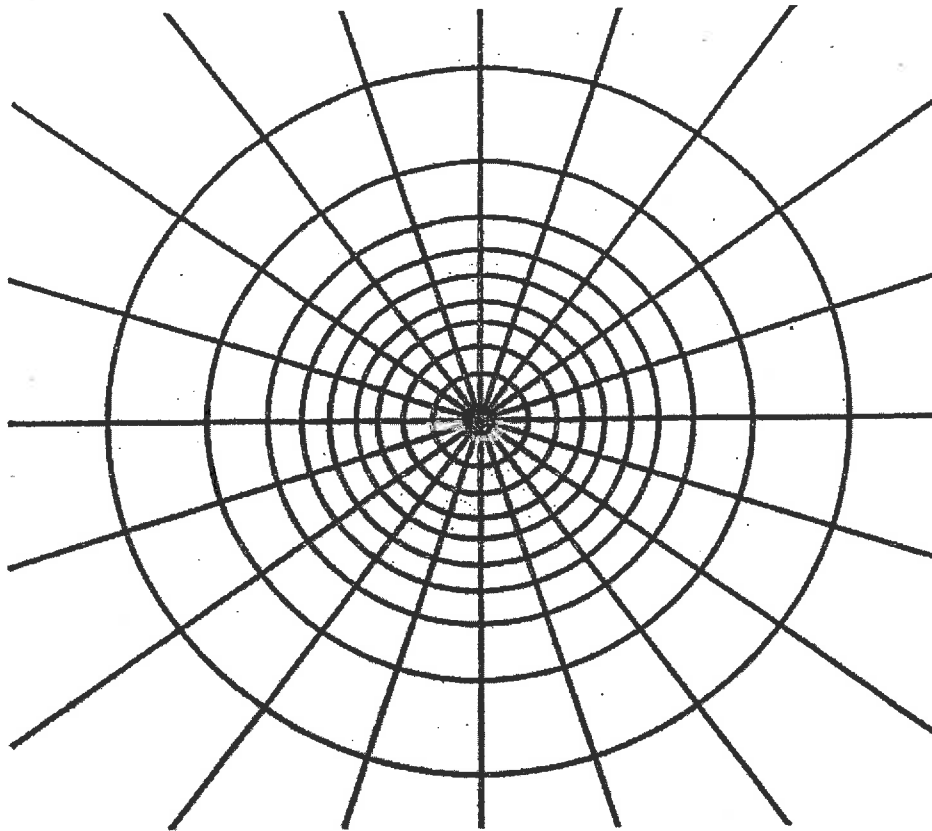


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Depth scale

$I_N = 0.005$

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

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

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

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

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

$$C_c = \frac{e_0 - e_1}{\log\left(\frac{\sigma_1'}{\sigma_0}\right)}; \text{ also, } C_c = 0.009(LL - 10);$$