

PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS - December 2011
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 ATotal 40 marks
Three out of four questions in 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

10 marks

Circle the correct answer.

1	The submerged density of soil, ρ_{sub} is always less than the density of water.	T	F
2	The dry density of a soil can be determined using the expression below: $\rho_d = \frac{G_s \rho_w}{1 + \frac{wG_s}{S}}$ where: G_s = specific gravity, ρ_w = density of water, w = water content, S = degree of saturation	T	F
3	The maximum value of liquid limit, w_L for any soil is 100%.	T	F
4	The saturated coefficient of permeability of silty sand is typically greater than that of a sandy silt.	T	F
5	The plasticity index, I_p of typical expansive clay is greater than that of sandy silt.	T	F
6	The effective cohesion of over-consolidated sample measured in the laboratory using triaxial tests is typically close to zero.	T	F
7	The vane shear test apparatus is the most reliable equipment for determining the effective shear strength parameters, c' and ϕ' of a soft saturated clay.	T	F
8	A clayey soil with the mineral montmorillonite has a lower coefficient of permeability in comparison to clays that have kaolinite or illite as clay minerals.	T	F
9	The dry density of an sandy silt at its optimum moisture content is higher than the dry density of a clay at its optimum moisture content	T	F
10	A uniformly graded soil has a good and equal representation of all particle sizes from the largest to smallest size of that particular group	T	F

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Question 2: Choose the correct answer. Also, justify the answer with reasonable explanation.

(Value: 4 +3+3 = **10 marks**)

(i)	Both the triaxial test and the direct shear test equipment can be used to determine the effective shear strength parameters (c' and ϕ') of sands as well as clays under drained loading conditions (i.e., CD tests).	T	F
(ii)	<div style="text-align: center;"> <p style="text-align: center;">Figure 1</p> <p>The seepage below the dam using the flow net and the other information shown in Figure 1 is equal to 3 m³/day per m width.</p> </div>	T	F
(iii)	Soil A is normally consolidated clay and Soil B is over-consolidated clay with a pre-consolidation pressure equal to 330 kPa. A five storey structure was constructed on these soils. The settlement in Soil B will be much lower than the settlement in Soil A (Assume each story will induce a stress equal to 10 kPa approximately).	T	F

Question 3:

(Value: **10 marks**)

Explain one-dimensional consolidation behavior with particular reference to effective stress principle using the spring analogy model shown in the **Figure 2** given below.

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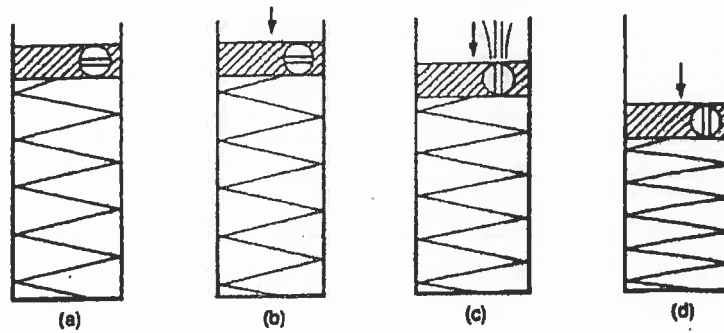


Figure 2

Question 4:

(Value: 10 marks)

As a junior engineer, you are asked to estimate the settlement that would arise due to the construction of a structure on a soil that predominantly has organic material such as peat. What test or tests do you undertake? What key properties or parameters would you derive from these tests? Also, how would you proceed with your analysis for estimating the settlement?

SECTION B

ANSWER THREE OF THE FOLLOWING FOUR QUESTIONS

Question 5:

(Value: 20 marks)

Calculate σ , u , and σ' variation with depth for the conditions in the soil profile shown below. Note H_1 , H_2 , H_3 are 4m, 2.5m, and 3.5 respectively. The degree of saturation in the capillary zone is 60%.

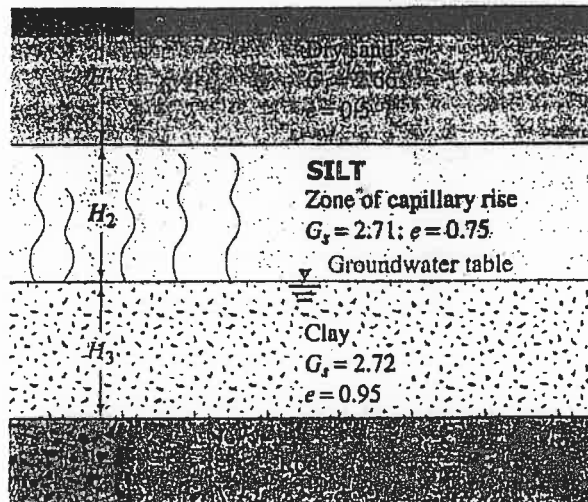


Figure 3

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A laboratory consolidation test on a clay sample obtained from the clay layer (in the depth zone of H_3) gave the following results:

Pressure (kN/m^2)	Void ratio
100	0.900
200	0.815

Determine the consolidation settlement in the clay layer if the average effective stress on the clay layer is increased by 100 kPa due to the construction of a structure. Assume the clay layer to be normally consolidated.

Question 6:

(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 one of the two methods

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

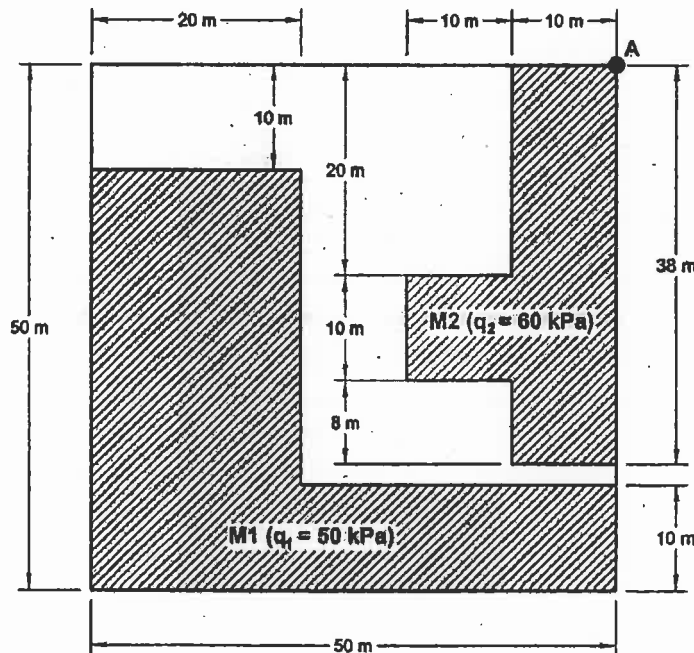


Figure 4

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Question 7:

(Value: **20 marks**)

For the cutoff wall shown in Figure 5

- a. Establish the **flownet** (i.e. flow and equipotential lines) following all the rules (draw on Figure 5). (10 marks)
- b. Calculate the **effective stress** at point A (back of the piling) ($\gamma_{sat} = 20 \text{ kN/m}^3$): (10 marks)

Effective stress (σ') = Total stress (σ) – Pore water pressure (u)

$u = (h - z)\gamma_w$

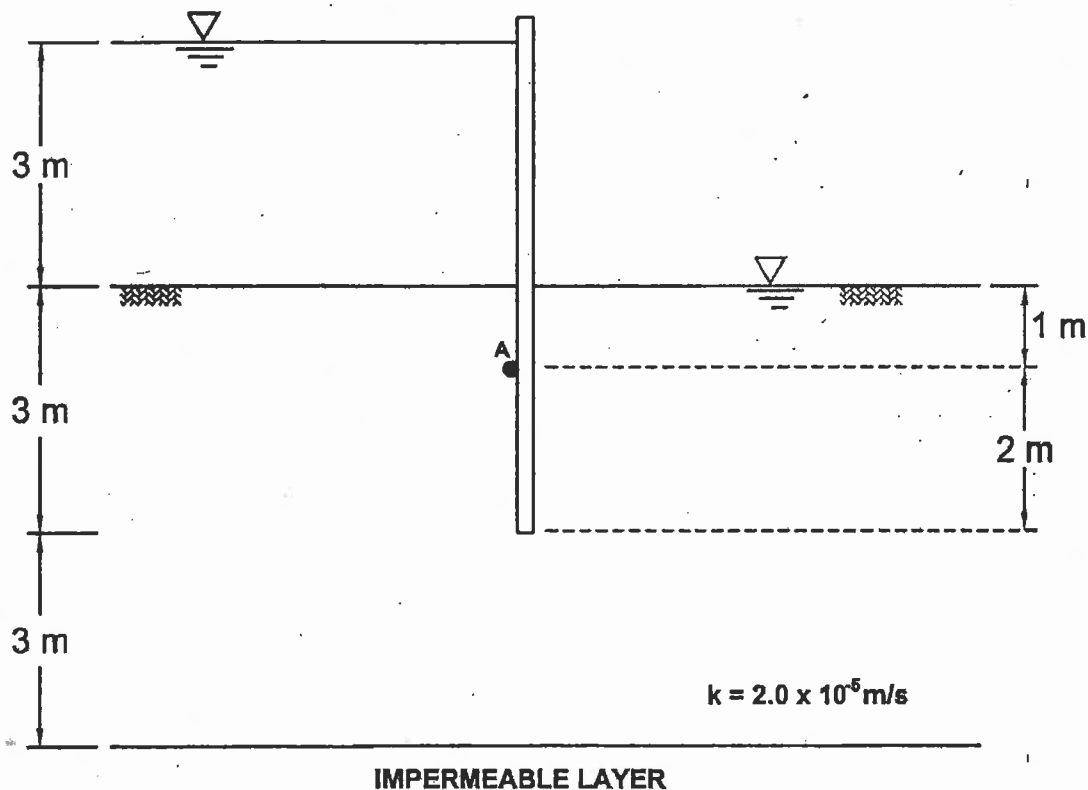


Figure 5

Question 8:

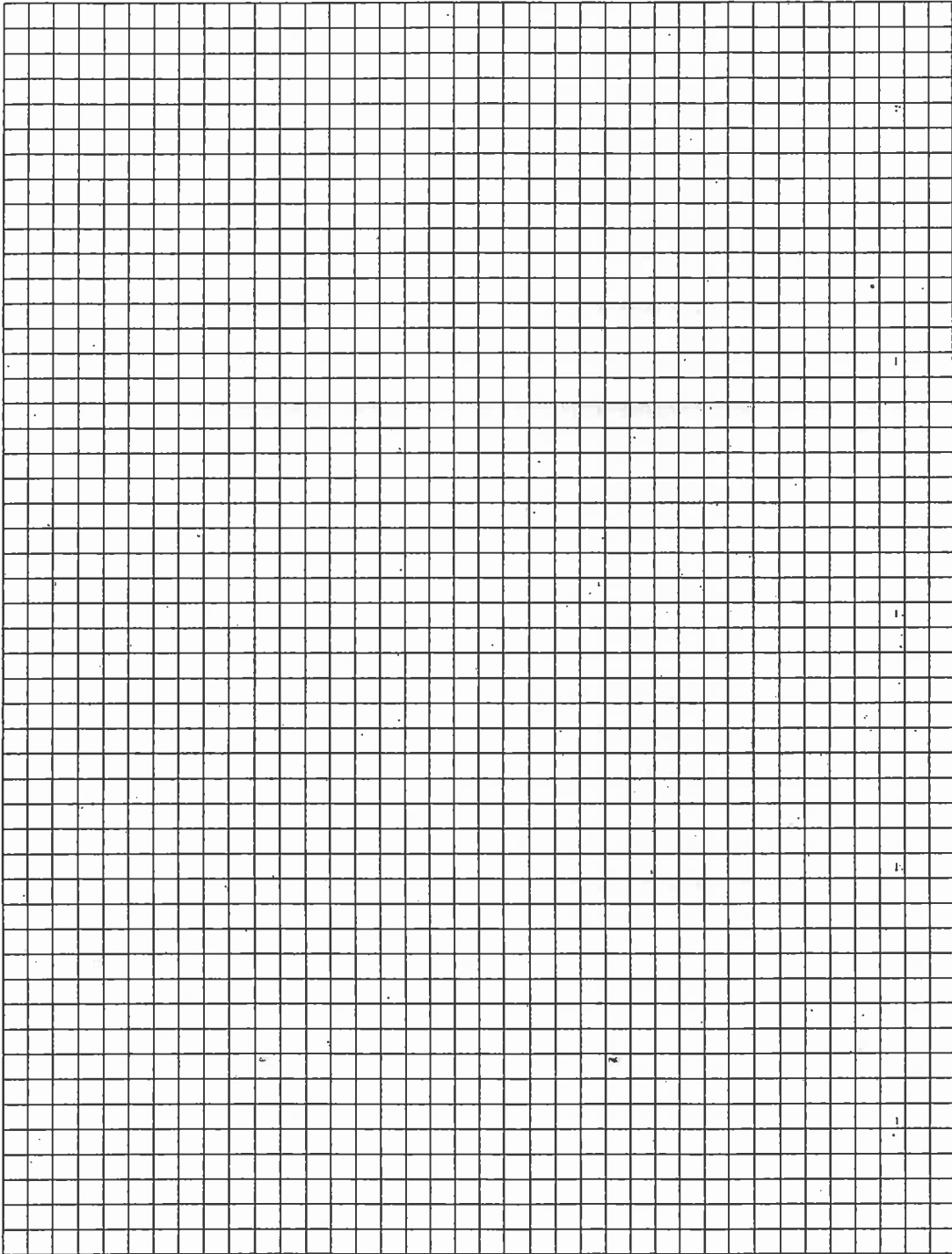
(Value: **20 marks**)

A consolidated-undrained triaxial test was conducted on a normally consolidated saturated clay. The following are the test results:

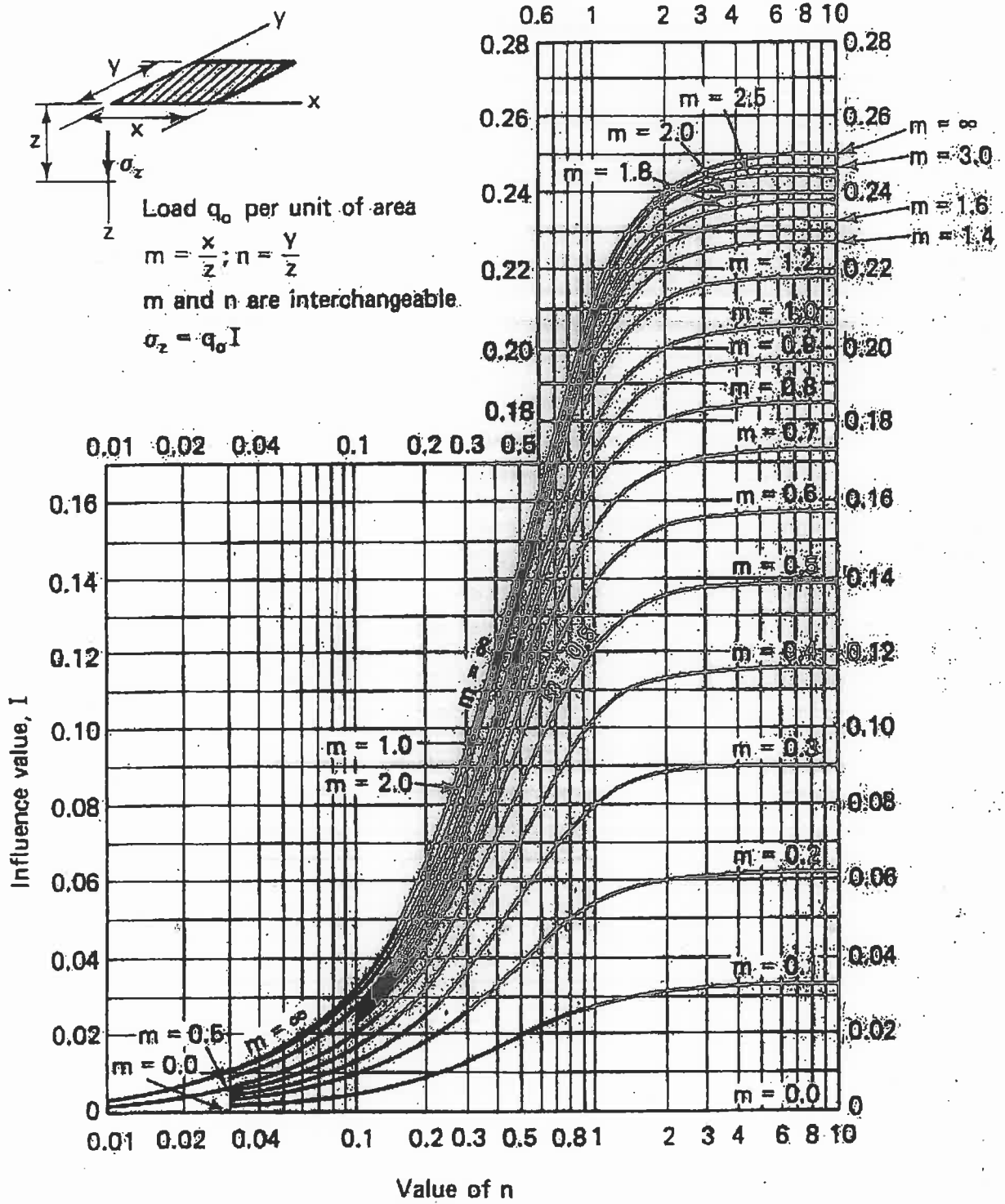
$\sigma_3 = 90 \text{ kN/m}^2$, $\sigma_1 \text{ (failure)} = 225 \text{ kN/m}^2$, pore-water pressure at failure, $u_f = 40 \text{ kPa}$.

Use any two different methods to determine the effective shear strength parameters. Also, what is the total shear strength for this soil. (undrained shear strength?)

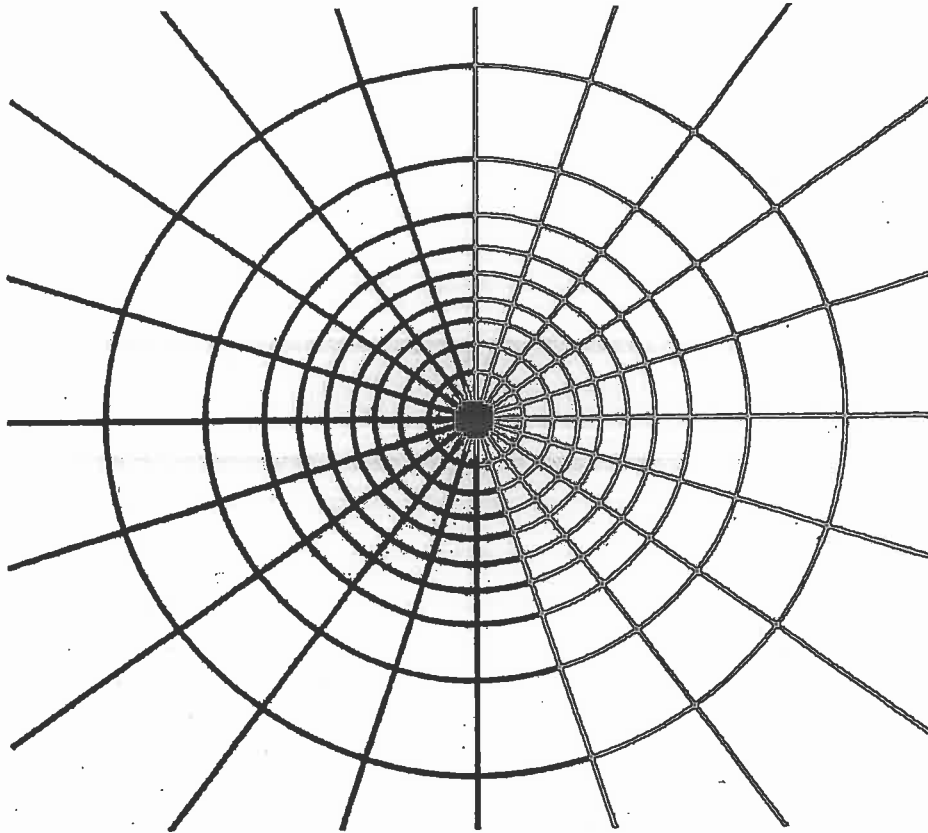
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Depth scale

$I_N = 0.005$

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

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

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

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

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

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