PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –December 2009
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 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. Also, provide reasons to justify the statement in your answer book along with the question number. Best five answers will be considered for this question.

(i)	Boussinesq's equation used for calculating the vertical stress distribution below the footings is not valid at a depth value equal to zero.	T	F
(ii)	The compression index, C_c for an over consolidated clay (i.e., Soil A) was determined from consolidation tests. The same clay (i.e., Soil A) was mixed with water at a content higher than its liquid limit and subjected to a loading below the preconsolidation pressure. The C_c value of the prepared normally consolidated clay is lower than the C_c value of the over consolidated clay specimen (i.e., Soil A).	T	F
(iii)	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
(iv)	The pore-water pressure in an over consolidated clay sample is always negative.	T	F
(v)	The degree of saturation of a compacted specimen at optimum moisture content is always lower than 100%	T	F
(vi)	The direct shear test apparatus is a versatile equipment and can be used for determining the shear strength of soils under different loading conditions for all soils including sands and clays (i.e., UU, CU and CD conditions).	T	F

Question 2: **(Value: 10 marks)**

a. A saturated soil (i.e., **S = 100%**) in a container that is subjected to a total stress, σ is shown in **Figure 1.** The level of water in a standpipe is the same as the surface of the soil (i.e. hydrostatic pore-water pressure). What will be the change in effective stress if an additional stress, $\Delta\sigma$ is applied on top of the total stress σ under undrained conditions? Briefly describe the reason (Note: u_s = hydrostatic pore-water pressure and u_e = excess pore-water pressure).

b. What different types of tests would you recommend to determine the effective shear strength parameters of granular and cohesive soils

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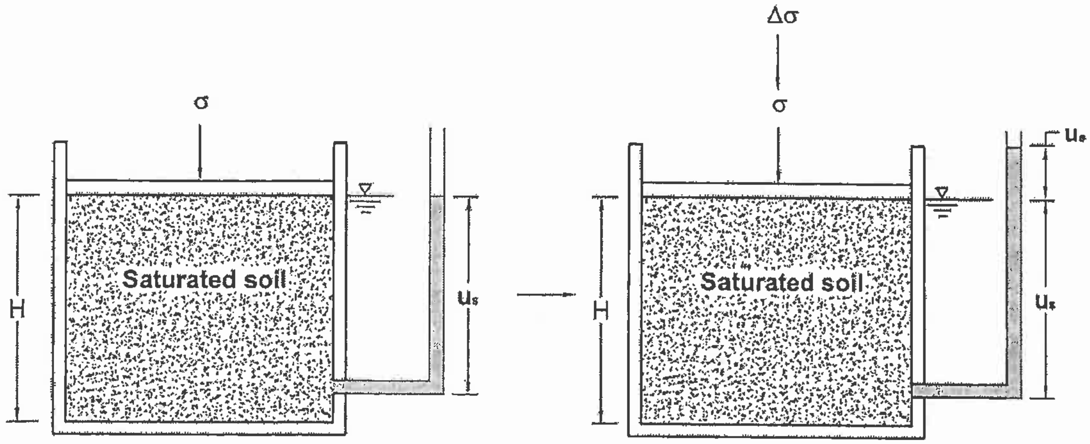

Figure 1

Question 3: (Value: 10 marks)

Water is seeping downward through saturated soil layers as shown in **Figure 2**. The flow conditions are at steady-state. For the soil profile given, calculate the total stress, pore-water pressure and effective stress at points **A**, **B**, and **C**.

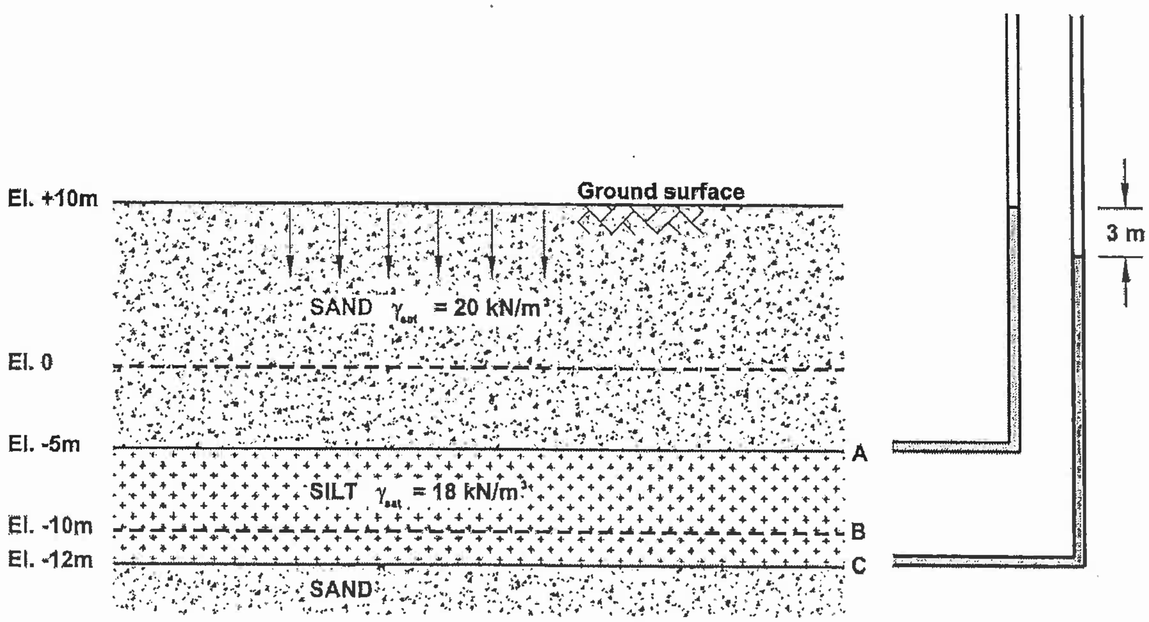

Figure 2

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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 (m^3/s per m) (coefficient of permeability, $k = 2.3 \times 10^{-5}$ m/s).

(iii) Calculate the effective stress at points A (back of the piling) and B (front of the piling) ($\gamma_{sat} = 20$ kN/m^3).

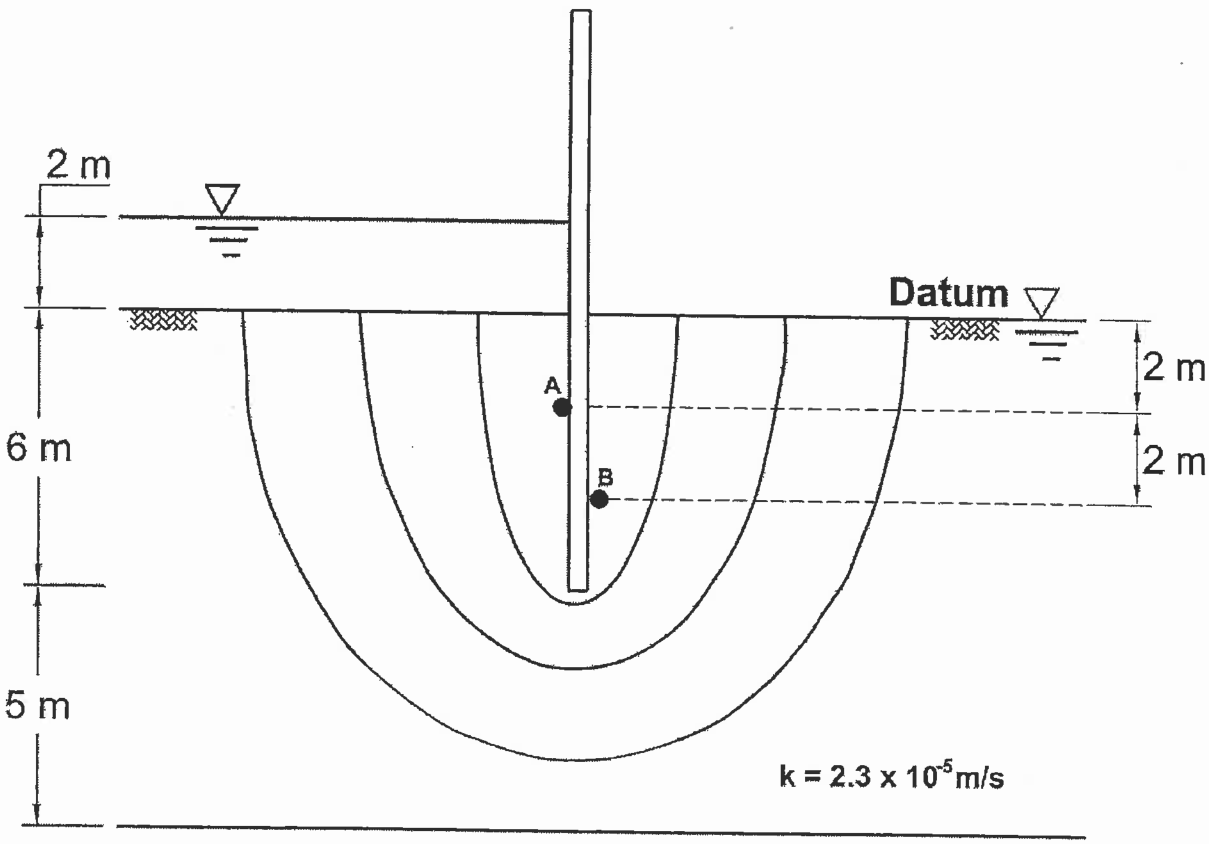

Figure 3

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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.

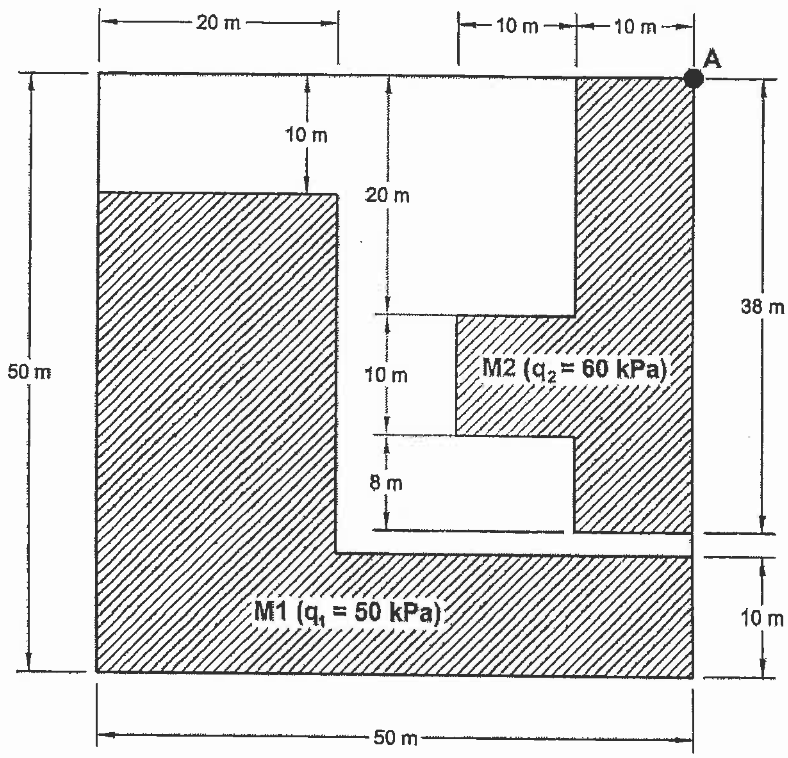

Figure 4

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

A series of 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 pressure (kN/m^2)	100	200	400	800
Principal stress difference (kN/m^2)	452	908	1810	3624

Determine the value of the angle of shearing resistance ϕ' analytically and also draw the Mohr circles to verify your result.

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Question 7: **(Value: 20 marks)**

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

(i) How long will it take for a similar clay layer 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.

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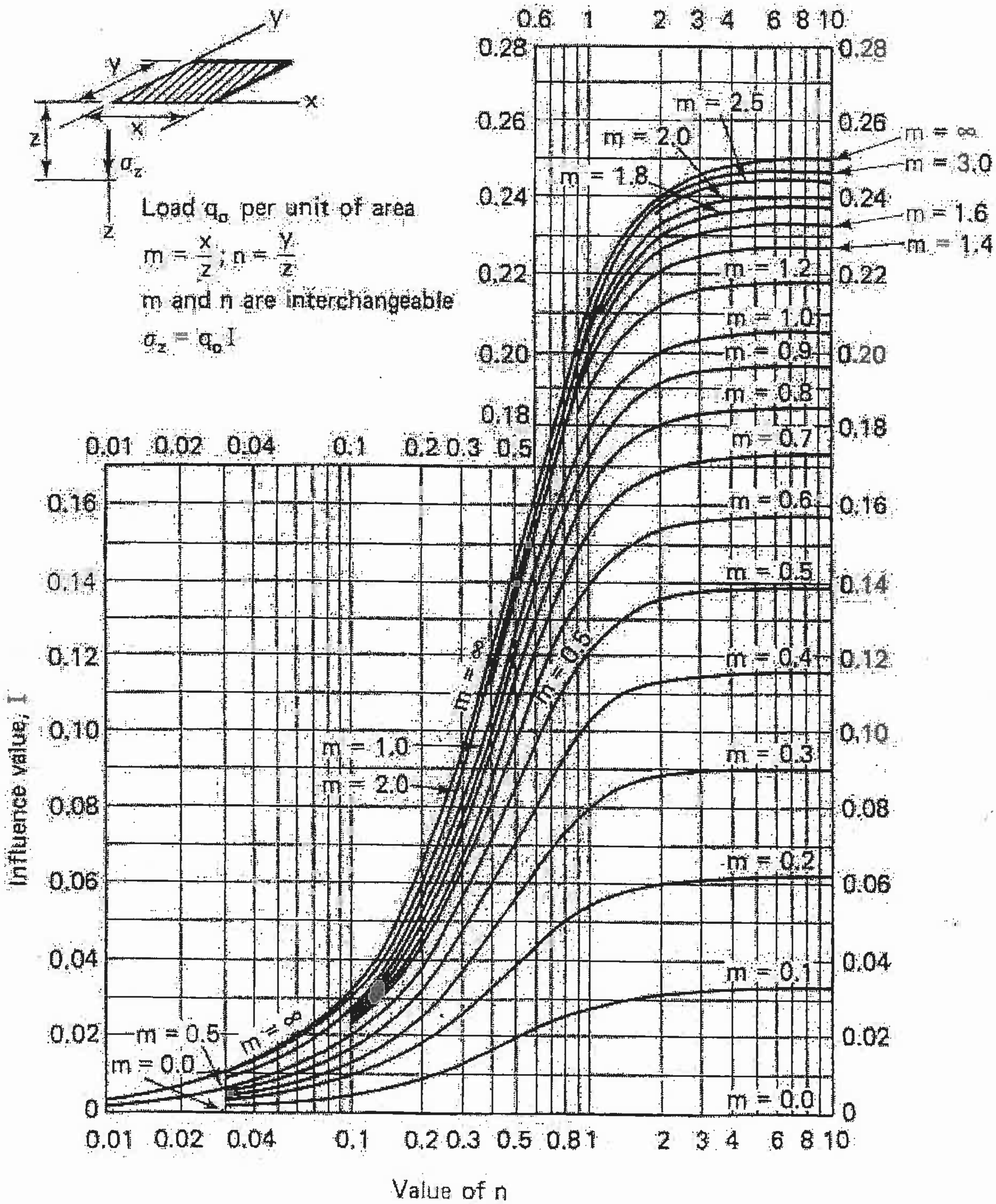

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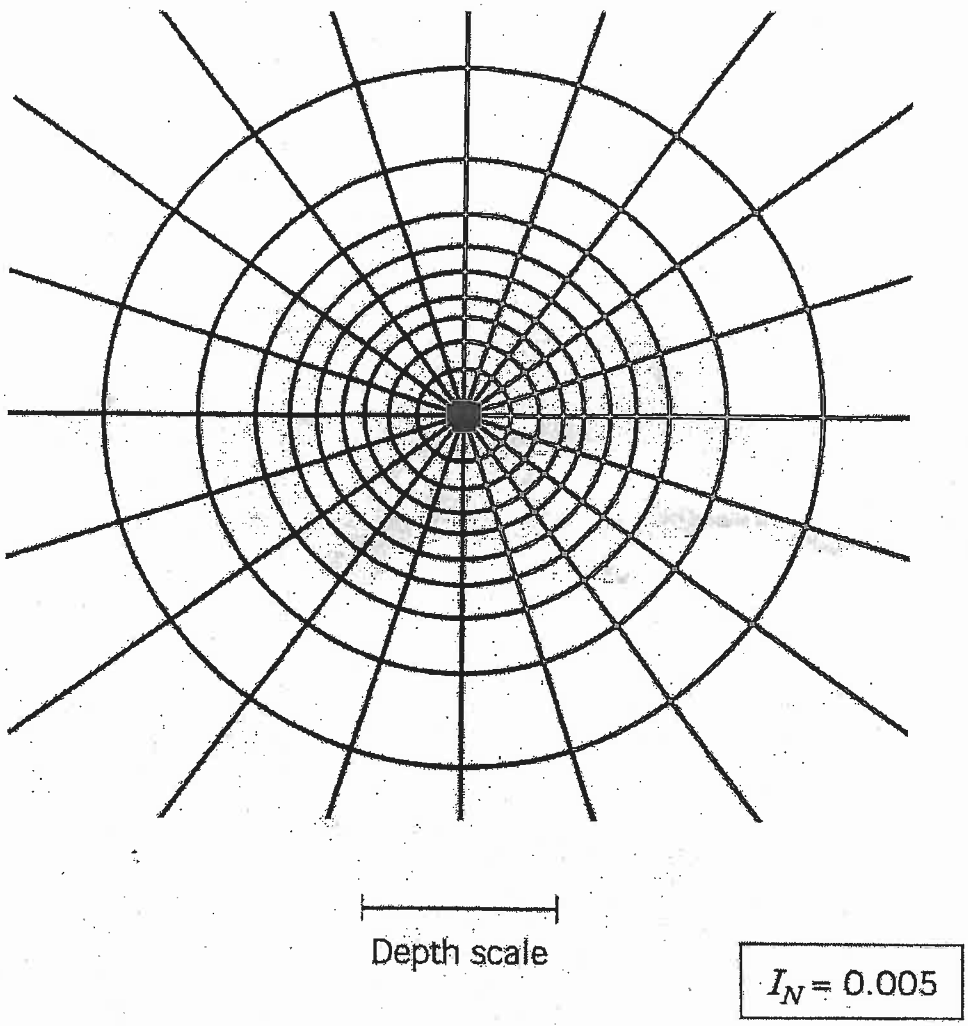

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Formula Sheet

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

$\sigma = \gamma D$

$P = \sum N' + uA$

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

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

$\sigma' = \sigma - u$

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

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

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

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

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

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

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