NATIONAL EXAMINATIONS –May 2019

07-Str-A3 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. All required charts and equations are provided at the back of the examination.
7. YOU MUST RETURN ALL EXAMINATION SHEETS.

ANSWER ALL QUESTIONS

Question 1: **(10 marks)**

1	The maximum size of clay particle is: (A) 2×10^{-6} m (B) 75×10^{-6} m (C) 100×10^{-6} m (D) 200×10^{-6} m
2	The optimum moisture content of a soil is close to the soil's: (A) Shrinkage limit (B) Plastic limit (C) Liquid limit (D) Plasticity index
3	One of the following soil properties decreases due to the compaction the soils (A) Strength (B) Permeability (C) Bearing capacity
4	The coefficient of permeability for fine-grained soils can be determined by one of the following tests (A) Falling head test (B) Constant head test (C) Piezometer test
5	The settlement in saturated clays are mainly attributed to (A) Deformation of soil grains (B) Compression of water within the voids (C) Expulsion of water from within the voids (D) Expulsion of soil grains
6	The stress versus strain behavior of an overconsolidated clay is similar to that of a dense sand. (A) True (B) False
7	The consolidated undrained triaxial test results with pore-water pressure measurements can only be used to estimate effective shear strength parameters. (A) True (B) False

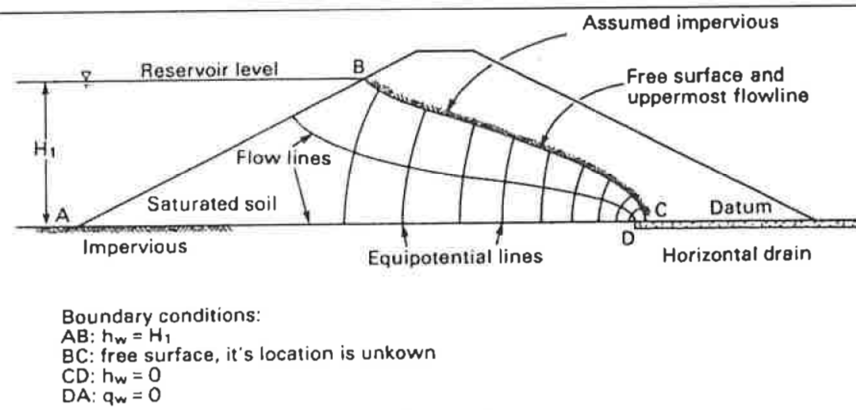
8	Which of the following statements is / are INCORRECT: (A) Overconsolidated clay generally has an effective cohesion equals to zero (B) Pore-water pressure can be negative during shearing for certain saturated clays (C) Volume reduction is expected during undrained triaxial shear tests (D) Consolidated drained triaxial test results can be used to analyze the long-term stability of an embankment
9	Which of the below is / are NOT one of the assumption(s) in the 1-D consolidation theory proposed by Terzaghi? (A) Homogeneous and 100% saturation (B) The coefficient of volume change, m_v and coefficient of permeability, k vary with respect to the effective stress (C) Drainage at both the top and bottom of the compressible layer (D) Soil grains and water are incompressible (E) Unique relationship between the volume change and effective stress
10	Which one of the tests below has a different drainage condition than the others? (A) Consolidated drained triaxial test on a fully saturated clay (B) Vane shear test on a fully saturated clay (C) Unconfined compression test on a fully saturated clay

Question 2: **(10 marks)**

State the correct answer in your ANSWER BOOK along with the Question number and explain the reason **for your answer**. Have all your answers for **Question 2** at one place. No mark will be awarded if reason is not provided.

PS: Some questions are not multiple choice questions. You have to answer those questions in a line or two.

1	Which one of the two samples: sample **A** (over consolidated clay) or **B** (normally consolidated clay) will exhibit greater peak strength from a consolidated drained test (i.e., ***CD***) test on sand (i): Sample **A** (loose sand) (ii) Sample **B** (dense sand)
2	Which one of the two samples: **C** (normally consolidated clay) or **D** (over consolidated clay with an ***OCR*** of 1) will exhibit greater peak strength for consolidated undrained tests (i.e., ***CU***) test on saturated clay: (i) Sample **C** (normally consolidated clay) (ii) Sample **D** (over consolidated clay with an OCR of 1) (iii) Both of them will be the same
3	Samples **E** and **F** are collected from the same site (i.e., they are identical samples – normally consolidated clay) and tested under **CU** and **CD** conditions in a triaxial test. Which sample; **E** or **F** will have higher shear strength when tested? Give your reason.

4	In a **CD** test on saturated dense sand the sample volume during shear (i) increases (ii) remains unchanged (iii) reduces
5	 **Figure 1** The pore-water pressure at C (i.e., top of horizontal drain) in a homogeneous earth dam is equal to (i) negative value (ii) atmospheric pressure (i.e., pore-water pressure is equal to zero) (iii) positive value

Question 3: **(Value: 15 marks)**

For a square footing of *4m x 4 m*, determine the average increase in stress at the centre of the area and at a depth of *5 m* due to a uniform loading of *100 kPa*. Use any three of the four different procedures (i.e., point load method, use *m* and *n* coefficients, Newmark's chart, and trapezoidal rule) and compare the results.

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

Following are the results of a consolidation test:

Void ratio, e	Pressure σ' (kN/m^2)
1.210	25
1.195	50
1.150	100
1.060	200
0.980	400
0.925	500

a. Plot the $e - \log \sigma'$ curve
b. Using Casagrande's method, determine the preconsolidation pressure.
c. Calculate the compression index C_c from the laboratory $e - \log \sigma'$ curve.

Question 5: **(Value: 15 marks)**

The flow net for a thin cutoff wall is shown in **Figure 2** below. If the coefficient of permeability, k is equal to 22 x 10^{-4} cm/sec, determine the seepage loss per meter of width. Also, determine the pressure head **only at point 5** shown in the Figure.

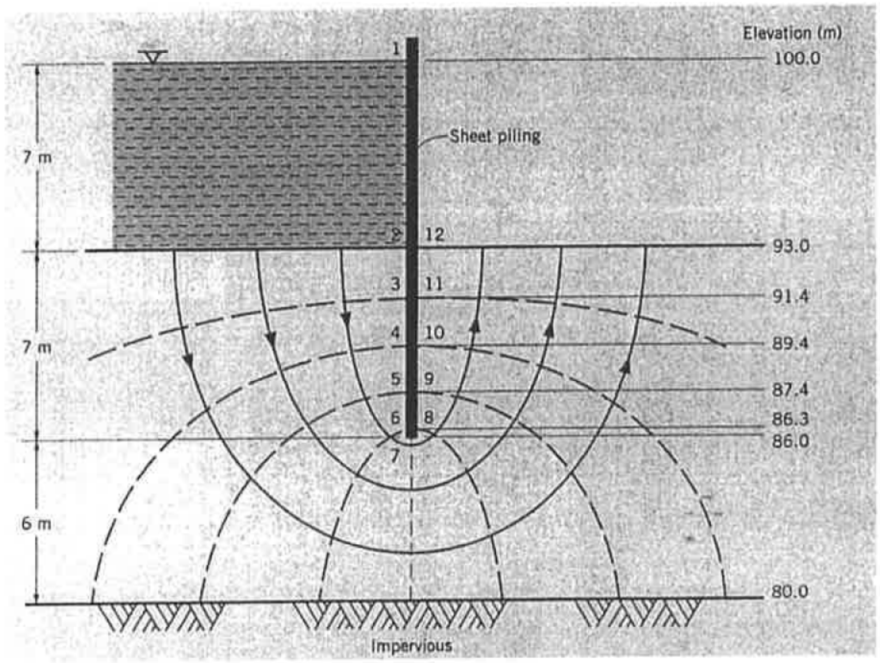


Figure 2

Question 6: **(Value: 30 marks)**

Table 1 summarizes the results of three series of consolidated-undrained ($\overline{CU}$) triaxial tests with pore water pressure measurements on fully saturated clay specimens at failure conditions.

Table 1. Consolidated undrained ($\overline{CU}$) triaxial test results at failure

Specimen	Confining stress, σ_3 (kPa)	Deviator stress, $(\sigma_1 - \sigma_3)$ kPa	Pore-water stress, u (kPa)
A	150	103	82
B	300	202	169

(i) Determine the effective shear strength parameters for the tested soil by plotting the modified failure envelope. **(10 marks)**

(ii) Determine the total shear strength parameters for the tested soil using a suitable analytical method. **(10 marks)**

(iii) If a specimen of the same soil were consolidated under an effective confining stress of 250 kPa (i.e. σ'_3 = 250 kPa), what would be the expected value of principal stress difference at failure? **(6 marks)**

(iv) Is the clay normally consolidated or overconsolidated? Give reasons. **(4 marks)**

Hint: Figure below may be useful for this question

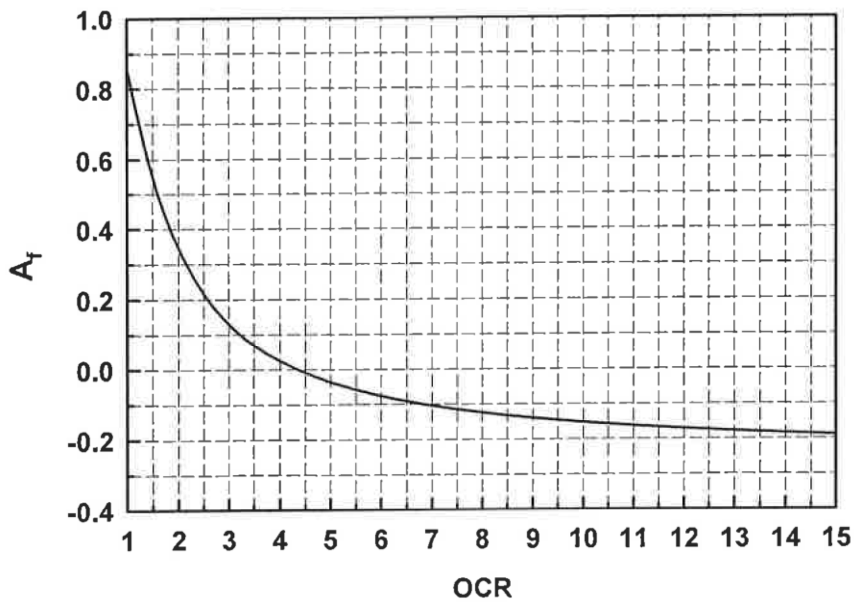
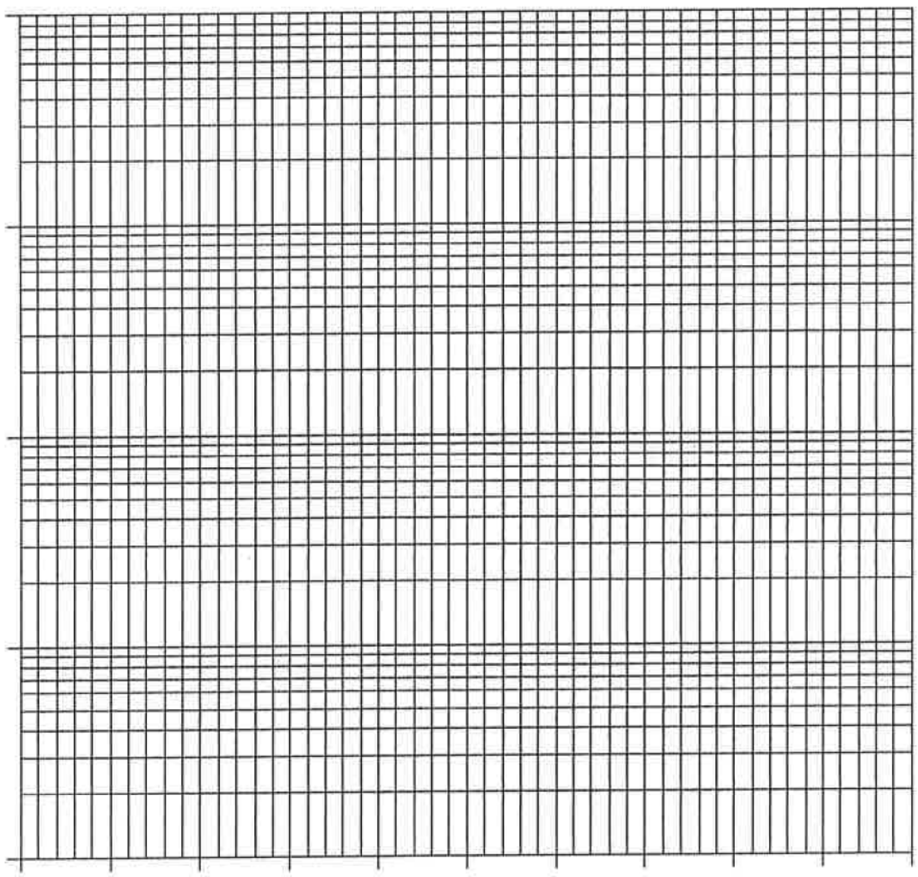
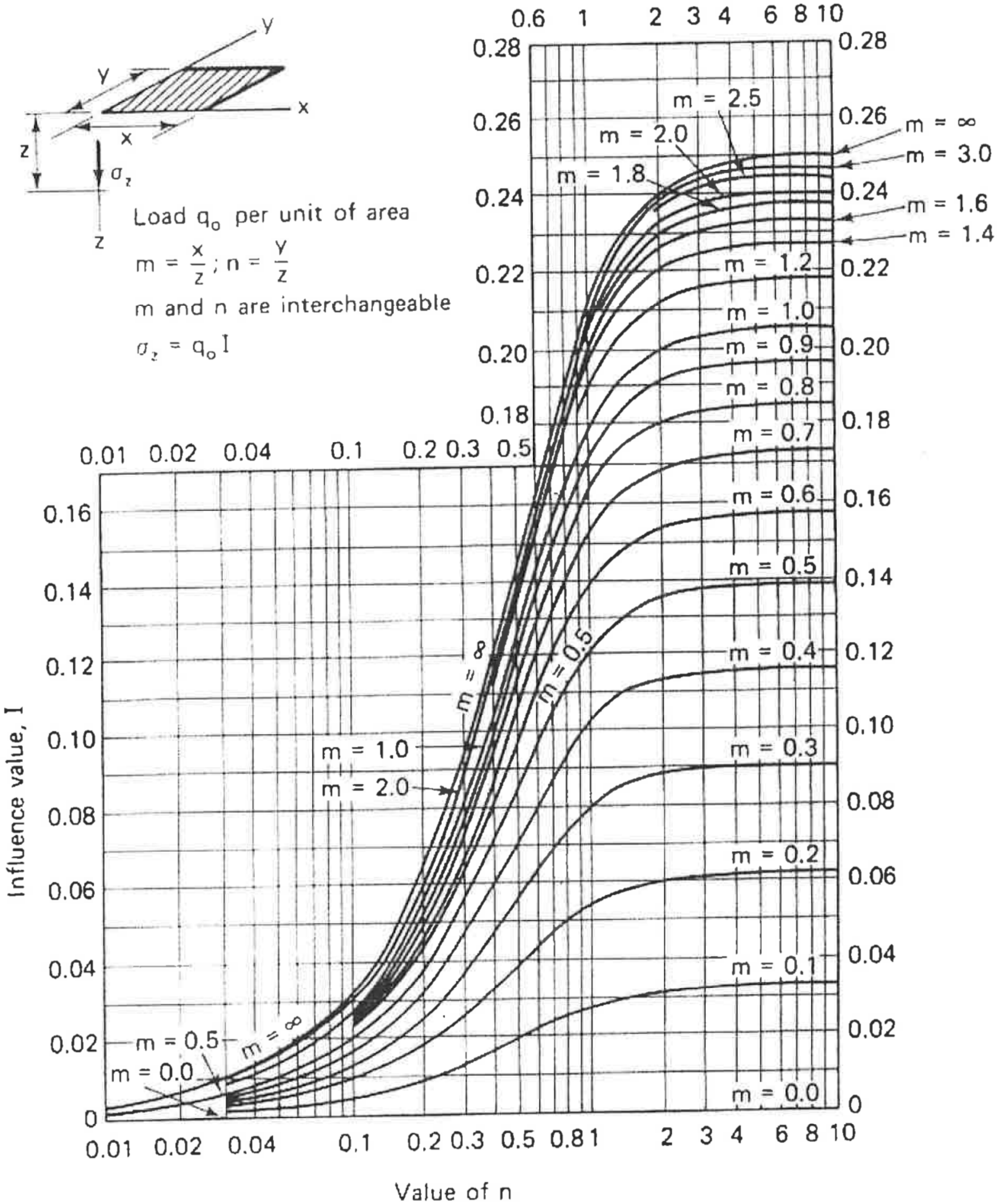
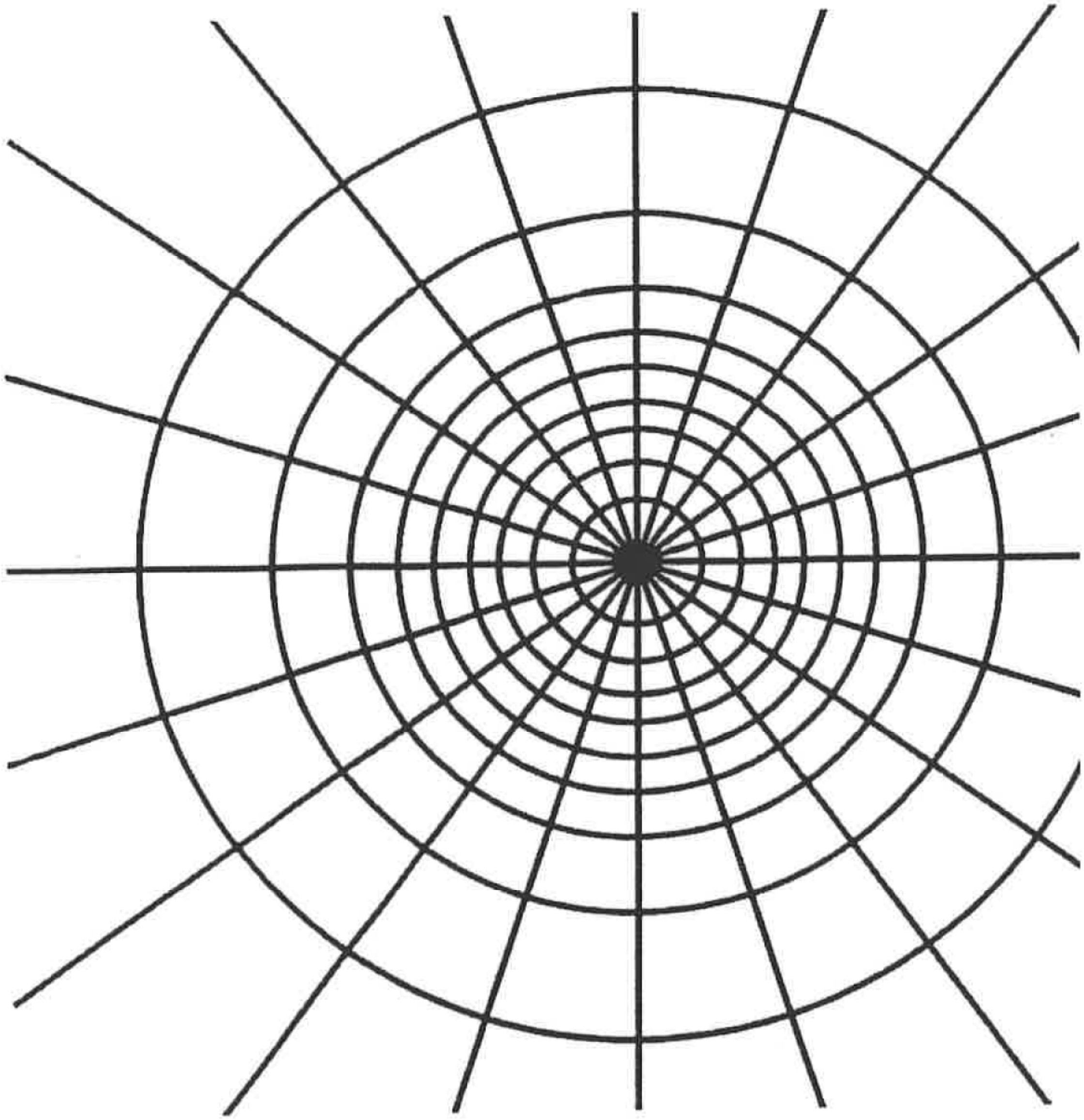


Figure 3. ***OCR*** **versus** A_f **relationship**




y
Y
x
X
z
σ_z
Load q_o per unit of area
$m = \frac{x}{z}$; $n = \frac{y}{z}$
m and n are interchangeable
$\sigma_z = q_o I$
Influence value, I
Value of n
m = ∞
m = 3.0
m = 2.5
m = 2.0
m = 1.8
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



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, $\sigma_z = \frac{q\,B\,L}{(B+z)(L+z)}$

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

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

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

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

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

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