NATIONAL EXAMINATIONS –May 2018

16-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 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)**

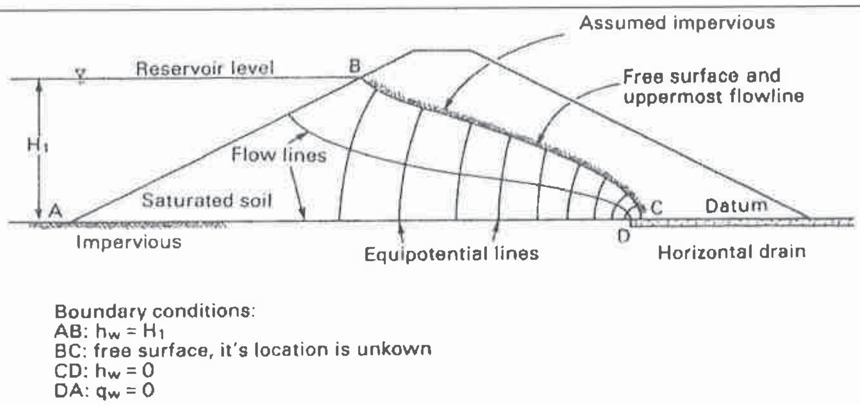
State the correct answer (**True or False**) in your ANSWER BOOK along with the **Question number**. Have all your answers for **Question 1** at one place.

1	A shallow square foundation with similar dimensions was constructed to carry a load of 200 kN on two different clayey soils. The first soil, **A**, was an over consolidated clay and the second soil, **B**, was a normally consolidated clay. Both soils are saturated and have the same density and initial void ratio. For the above soil conditions and the chosen foundation; overconsolidated clay (i.e., **A**) will typically settle less in comparison to normally consolidated clay (i.e., **B**).	**T**	**F**
2	The pore-water pressures measured in normally consolidated clay in a triaxial test can sometimes be negative, depending upon the stress applied on the specimen.	**T**	**F**
3	Plasticity index (I_p), plastic limit (PL) and liquid limit (LL) values for two soils; Soil **C** and Soil **D** are summarized below: Soil **C**: I_p = 30 %; PL= 30 %; LL= 60% Soil **D**: I_p = 30 %; PL= 20 %; LL= 50% Based on the above summarized information of soil properties, Soil **D** will have a higher Compression index, C_c	**T**	**F**
4	Significant volume change occurs in a saturated clay soil when the total stress is increased rapidly.	**T**	**F**
5	30% of the consolidation at a site subjected to a load of 100 kN/m^2 occurred in 3 months. If the site had been loaded to 300 kN/m^2, 90% of the consolidation would occur in a period of 9 months.	**T**	**F**
6	The effective cohesion, c' value can never be a negative value irrespective of the soil being an over-consolidated or a normally consolidated clay.	**T**	**F**
7	Compression index, C_c for a normally consolidated clay is not a function of effective stress.	**T**	**F**
8	The stress versus strain behavior of an overconsolidated clay is similar to that of a dense sand.	**T**	**F**
9	The settlements in saturated clays are mainly attributed to compression of water within the voids.	**T**	**F**
10	The amount of volume change that will occur when a soil is subjected to load depends on the coefficient of permeability, k, of the soil.	**T**	**F**

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** (loose sand) or **B** (dense sand) 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 10) 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 10)
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 normally consolidated clay, the sample volume during shear (i) increases (ii) remains unchanged (iii) reduces
5	 **Figure 1** The pore-water pressure along the upper most flow line (i.e., phreatic surface, BC) 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)**

What type of tests and equipment do you recommend to determine the shear strength parameters for loadings shown in **Figure 2** below for **(b) and (d)**? Note in Figure 2(b) the drainage valve is closed and the soil (represented as a spring) is loaded. In Figure 2d the drainage valve is open and the soil is loaded. Assume the spring in the Figure represents a normally consolidated clay. Also, **draw** typical **shear strength envelopes** for both these loadings. In addition, give a practical example for each of the tests where you use these shear strength tests in practice. **(5 marks + 5 marks +5 marks)**

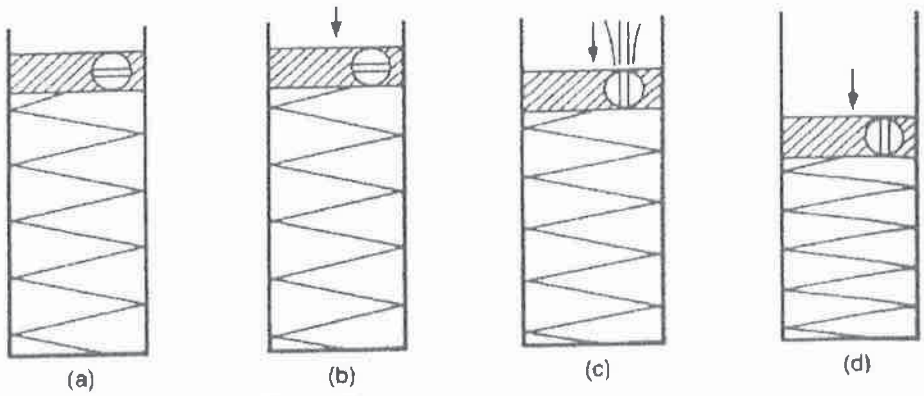


Figure 2: Consolidation analogy model

Question 4: **(Value: 25 marks)**

The following results were obtained from an oedometer test (i.e., consolidation test) on a specimen of saturated clay:

Pressure (kN/m^2)	27	54	107	214	429	214	107	54
Void ratio	1.243	1.217	1.144	1.068	0.994	1.001	1.012	1.024

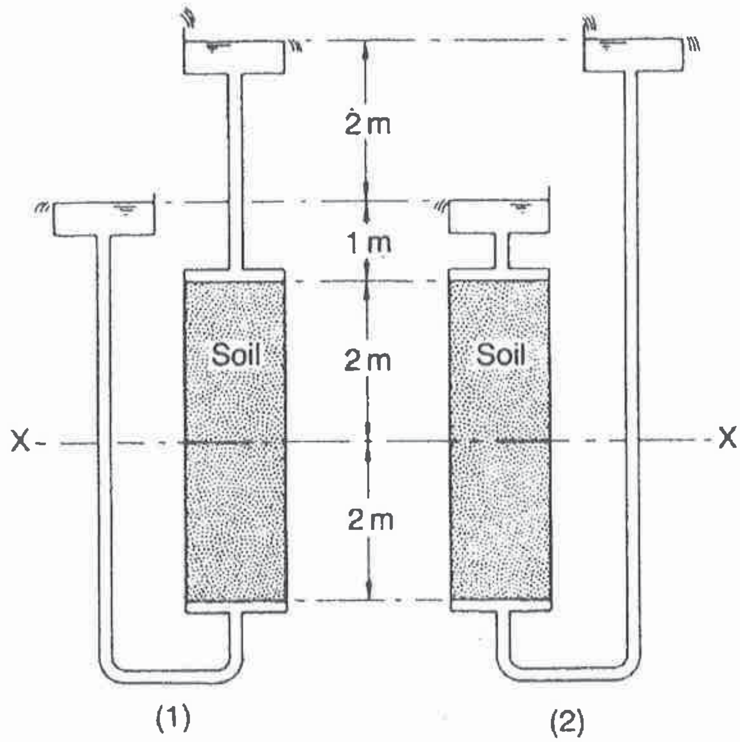
A layer of this clay 8m thick lies below a 4m depth of sand, the water table being at the surface. The saturated unit weight for both soils is 19 kN/m^3. A 4m depth of fill of unit weight 20 kN/m^3 is placed on the sand over an extensive area.

a. Determine the settlement due to consolidation of the clay.

b. If the fill was removed some time after the completion of consolidation, calculate the heave or consolidation that would eventually take place due to swelling of the clay?

Question 5: **(Value: 20 marks)**

For the seepage situations shown below, determine the effective stress on plane X-X for both the situations (1) and (2). Note: $\gamma_{sat} = 20\ kN/m^3$



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

The plan of a flexible rectangular loaded area is shown in **Figure 3. It** is uniformly distributed with an intensity of loading $q = 90\ kN/m^2$. Determine the vertical stress increase, $\Delta\sigma_z$, at a depth of $z = 2\ m$

(i) below point **C** using the ***m and n*** coefficients method, and

(ii) below point **B** using Newmark's method.

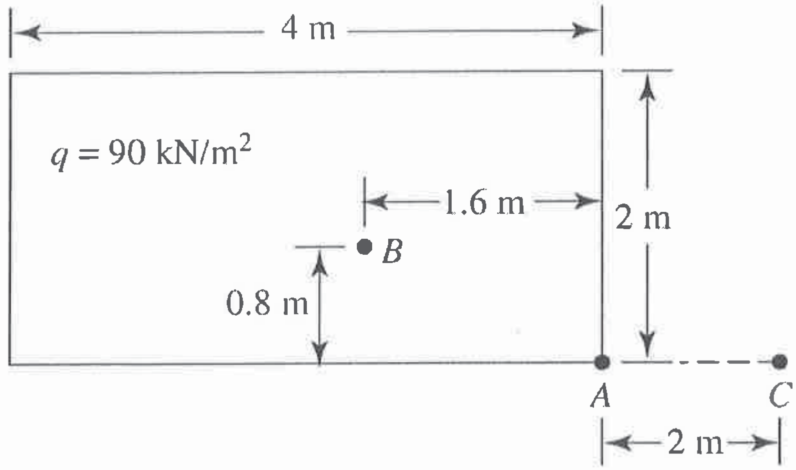
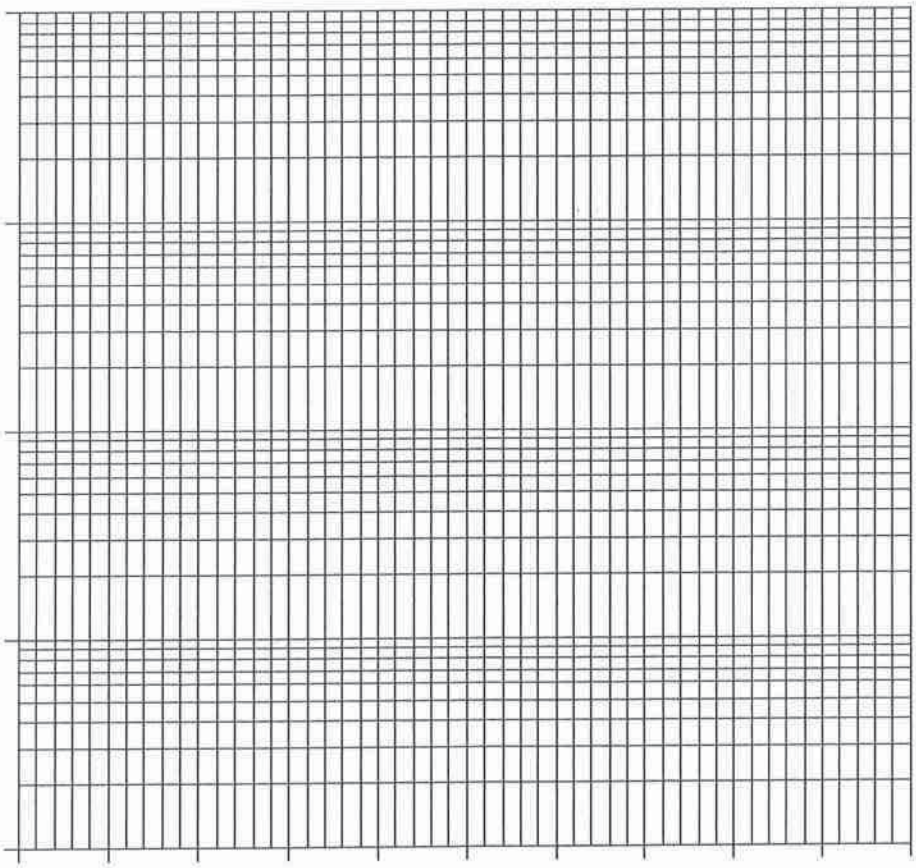
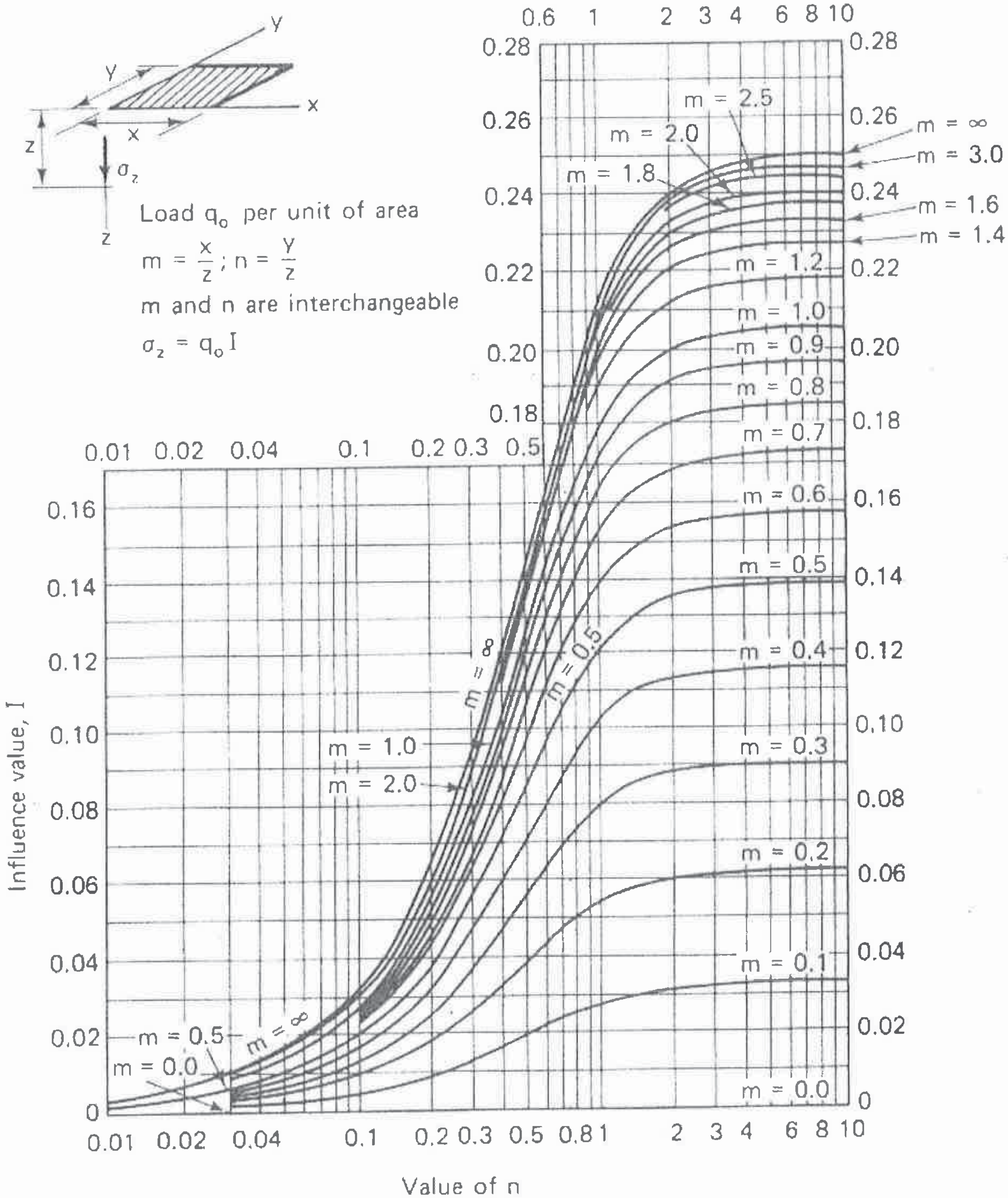
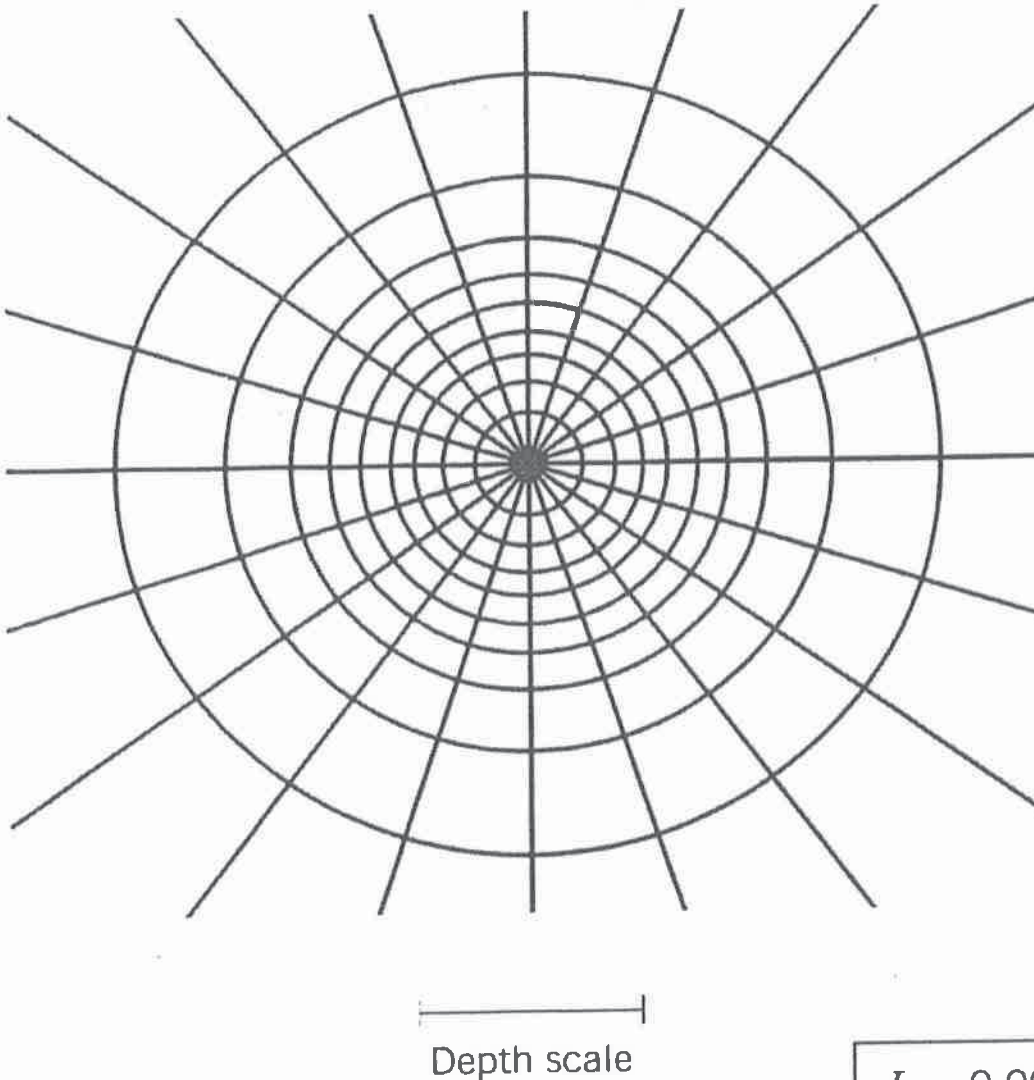


Figure 3




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



$I_N = 0.005$

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, $C_c = 0.009(LL - 10)$;