NATIONAL EXAMINATIONS –December 2018
07-BLD-A6 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. Drawing instruments are required.
7. All required charts and equations are provided at the back of the examination.
8. YOU MUST RETURN ALL EXAMINATION SHEETS.

SECTION A

ANSWER ALL QUESTIONS

Question 1: **(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. Have all your answers to this question at the same place.

(a) Which one of the following sandy soils will have a higher saturated coefficient of permeability? Give reasons:

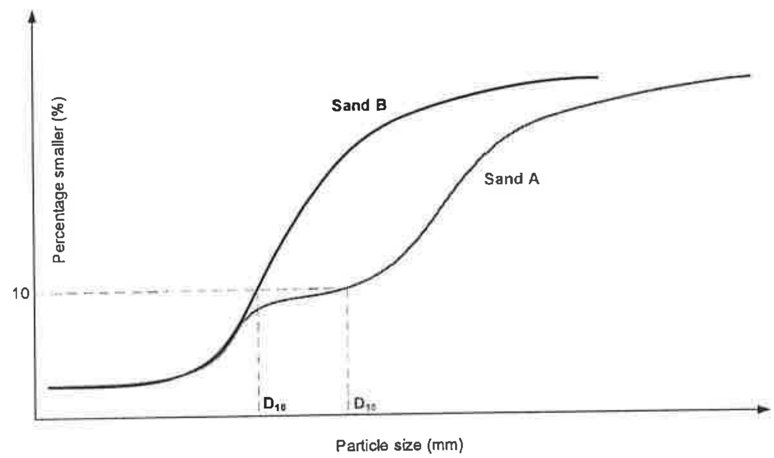


Figure 1

(i) Sand A
(ii) Sand B
(iii) Sands typically have the same coefficient of permeability

(b) If both sands in **Figure 1** (i.e., sand A and sand B) liquefied under the impact of an earthquake, which one of the statements below is true.
(i) Sand A has a higher shear strength than sand B.
(ii) Sand B has a higher shear strength than sand A.
(iii) Both sand A and sand B will have approximately the same shear strength.
(iv) Both sands A and sand B will have no shear strength.

(c) The total shear strength parameters for a fine-grained soil can be determined using one of the following series of triaxial tests
(i) **UU** tests (ii) **CU** tests (iii) **CD** tests

(d) The bearing capacity of a square foundation at the surface of a sand with a ground water table (GWT) at a depth of five times the width (B) of the square foundation is 300 kPa. What will be the bearing capacity if the GWT rises to the natural ground surface?

	Hint: $q_{ult} = c'N_c + \gamma DN_q + 0.5\ \gamma BN_\gamma$ (i) approximately 150 kPa (ii) approximately 300 kPa (iii) reduces to zero
(e)	The zero-air voids line is: (a) Typically above the compaction curve and can be plotted without conducting any compaction tests, if the information of specific gravity of the soil is available. (b) Can be above or below the compaction curve and has to be determined conducting compaction tests at different water contents following standard testing procedures.

Question 2: **(10 marks)**

A proposed embankment fill requires 9000 m^3 of compacted soil. The void ratio of the compacted soil is specified as 0.72. Two borrow pits are available as described in the following table, which lists the respective void ratios of the soils and the cost per cubic meter for moving the soil to the proposed construction site. Make the necessary calculations to select the pit from which the soil should be bought to minimize the cost. Assume G_s to be equal to 2.67 for Borrow pit A and **2.7** for Borrow pit B.

Borrow Pit	Void Ratio	Unit Cost ($/m^3)
A	0.82	9
B	0.93	7

Question 3: **(10 marks)**

Calculate the effective stress for a soil element at depth 5m in a uniform deposit of soil (**see Figure 2**). Given that specific gravity of the soil, $G_s = 2.7$.

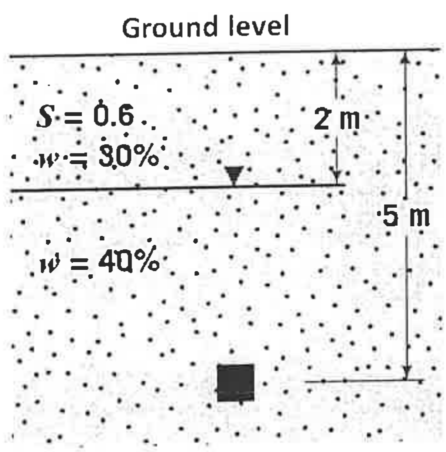


Figure 2

SECTION B

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

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

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

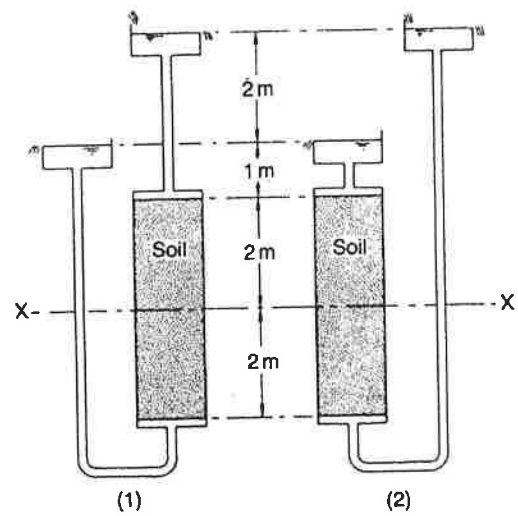


Figure 3

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

The plan of a flexible rectangular loaded area is shown in **Figure 4**. The uniformly distributed load on flexible area, **q** is 100 kN/m^2.

(i) Determine the vertical stress increase, $\Delta\sigma_z$, at depth of z = 2m below **Point C using any of the suitable methods**. Comment on the relative stress values for point A and B at the same depth of z = 2m, without any mathematical calculations.

(ii) Comment if the vertical stress values at A, B and C would increase or decrease at a depth of z = 5m in comparison to vertical stress, values at z = 2m. No calculations should be performed for answering this question.

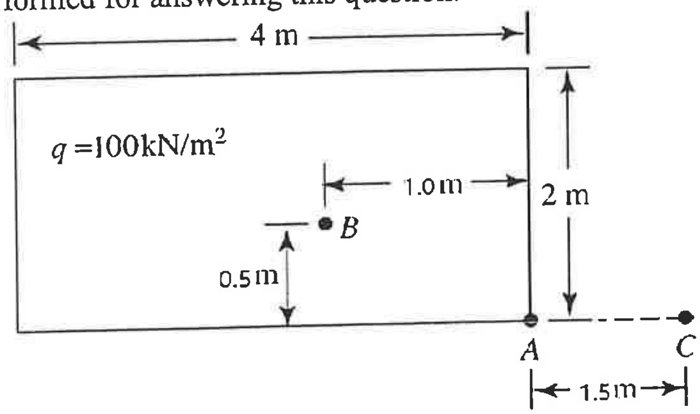


Figure 4

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

The results in **Table 1** given below were obtained at failure conditions in a series of consolidated-undrained triaxial tests with pore water pressure measurements on fully saturated clay specimens.

a) Determine the **total shear strength parameters (c, ϕ)** for the tested soil using an **analytical procedure (rather than graphical)**.

Table 1

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

b) Can you use the above triaxial shear strength test results summarized in Table 1 to determine the short term stability of an earthen structure constructed with this soil. If your answer is YES to this question, explain how you can determine them. If your answer is NO, provide reasons why these are not useful.

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

Assume that the void ratio variation with respect to pressure shown in **Figure 5(a)** is representative of the clay shown in **Figure 5(b)**, determine the settlement under the centre of the footing. Assume, specific gravity $G = 2.7$

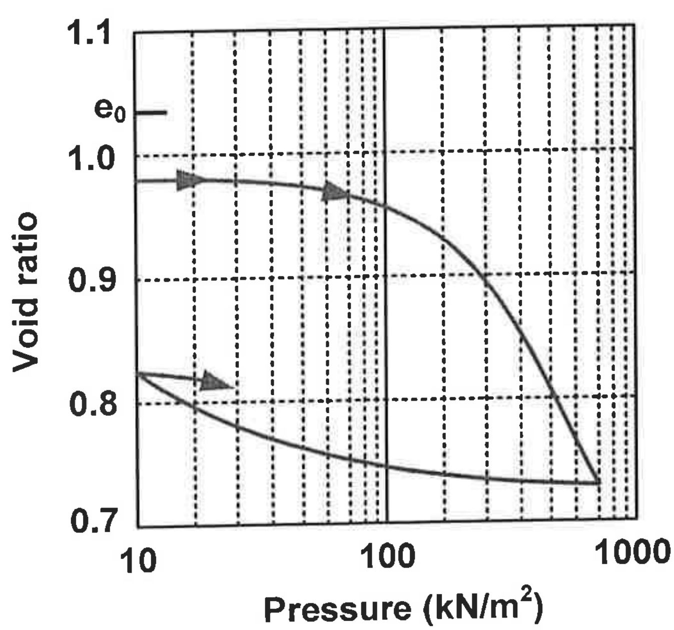


Figure 5(a)

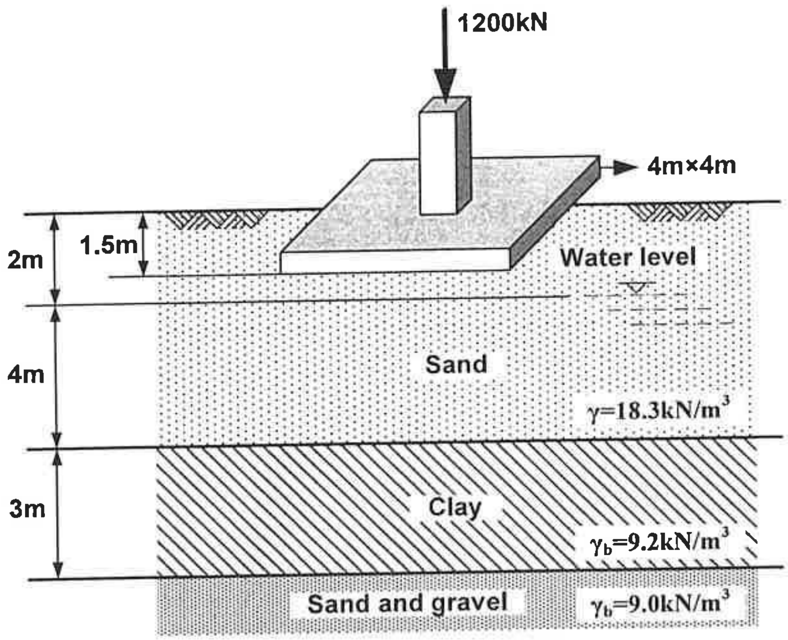
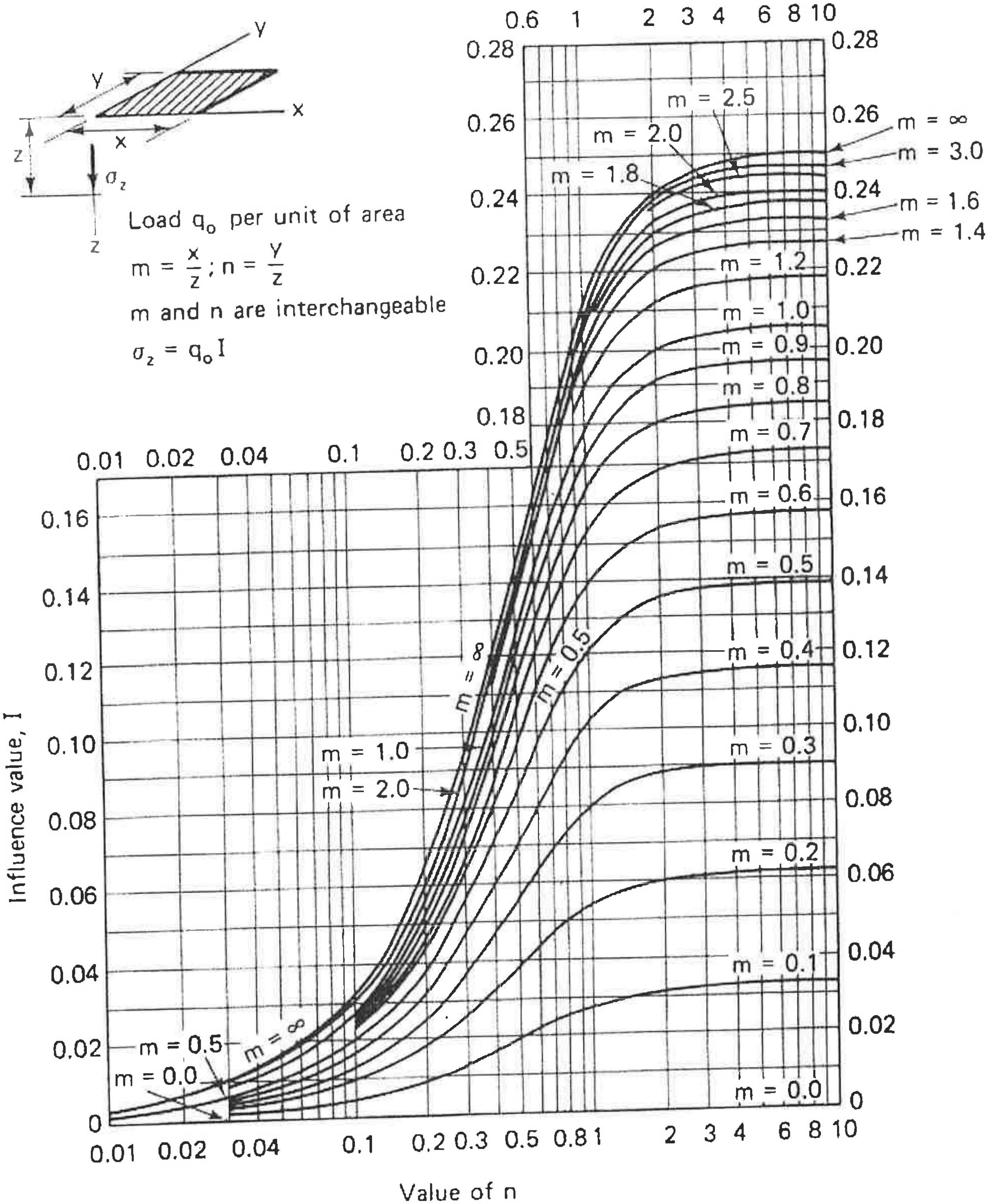
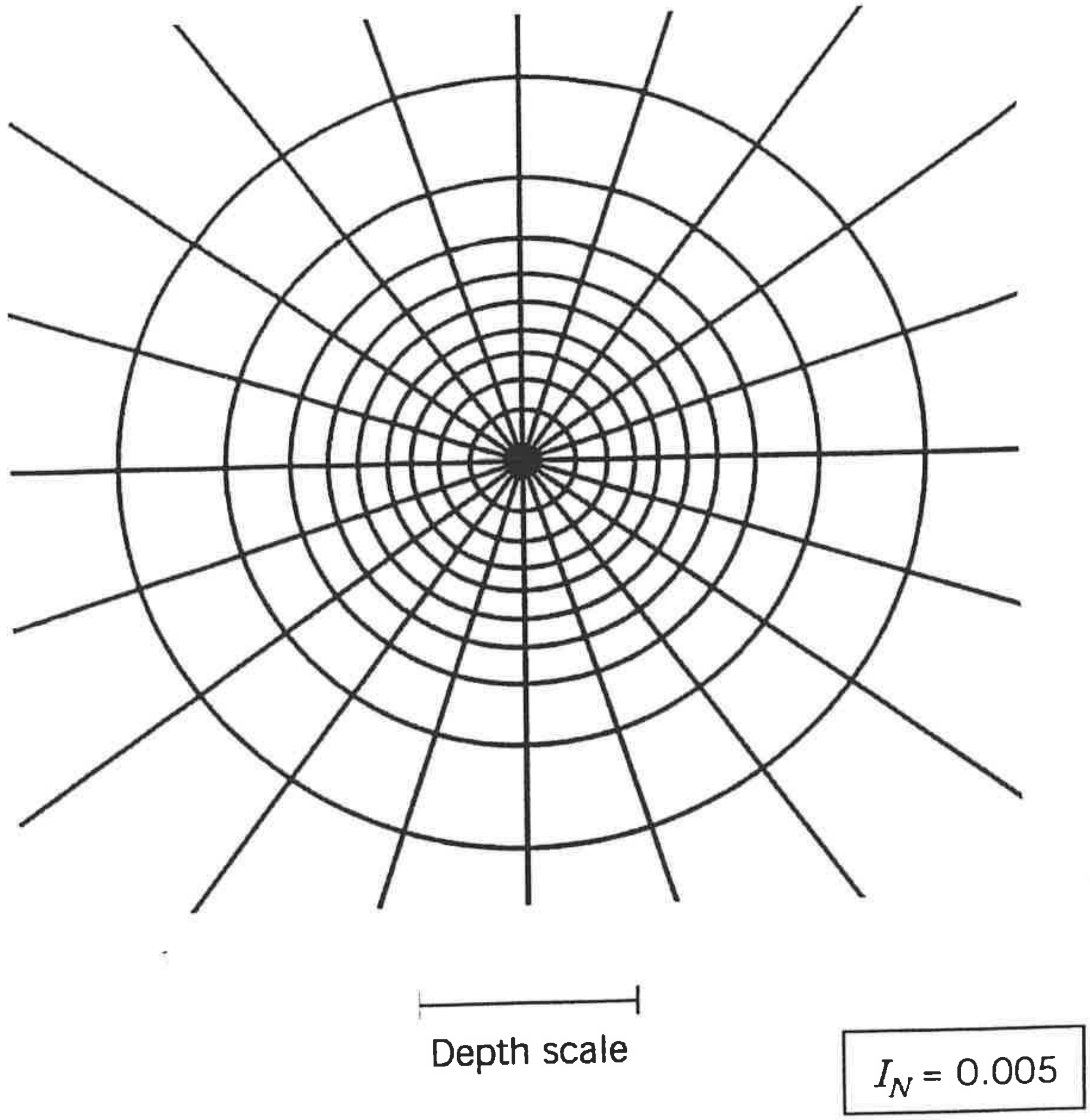

1200kN
4m×4m
2m
1.5m
Water level
4m
Sand
γ=18.3kN/m³
3m
Clay
γb=9.2kN/m³
Sand and gravel
γb=9.0kN/m³

Figure 5(b)


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


Depth scale
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, $\sigma_z = \frac{qBL}{(B+z)(L+z)}$

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

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

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

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