PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –May 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)	Assume you are swimming in a swimming pool at a depth of 5m below from the top surface of water. One of the following statements is true with respect to pressure on your body: (i) There is no pore-water pressure as there are no pores in water. (ii) The total stress is equal to pore-water pressure (iii) The effective stress is equal to pore-water pressure (iv) None of the above are correct
(b)	Liquefaction is more likely to occur in a (i) sand; (ii) soft clay; (iii) stiff clay under the impact of dynamic load
(c)	The shear strength parameters, c and ϕ values can be determined using one of the following triaxial tests (i) **UU** tests (ii) **CU** tests (iii) **CD** tests
(d)	Bearing capacity of a square foundation in sand with a ground water table (GWT) at a depth (D) of five times the width (B) of square foundation is 600 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) 600 kPa (ii) approximately 300 kPa (iii) reduces to zero
(e)	In a triaxial **CD** test on a saturated dense sand, the sample volume change under a low confining pressure of 10 kPa during shear (i) increases (ii) remains unchanged (iii) reduces

Question 2: **(10 marks)**

Figure 1 shows typical compaction curve for a fine-grained soil. As can be seen, dry unit weight (γ_d) increases with increasing compaction water content (w) up to a certain value

($w = w_2$) and then starts decreasing with further increase in compaction water content. Explain the reason associated with such a behavior for fine-grained soils.

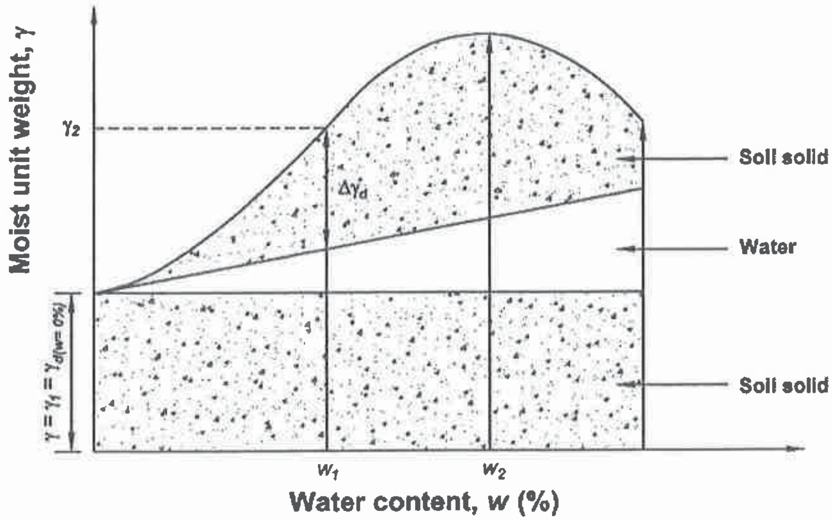


Figure 1. Typical compaction curve

Question 3: **(10 marks)**

Explain how the various stages shown in **Figure 2** can be compared with the consolidation process in saturated clay using the spring, piston, and valve (note both the closed and open positions of the valve)).

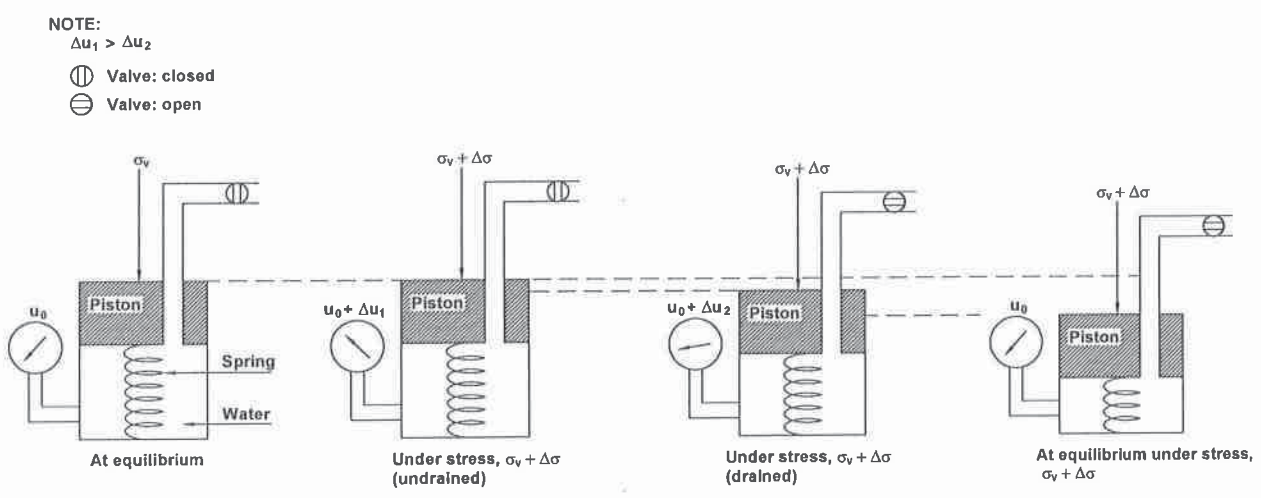


Figure 2

SECTION B

ANSWER ANY THREE OF THE FOLLOWING FOUR QUESTIONS

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

For a sheet piling driven 6.00m into a stratum of soil 8.60m thick (see **Figure 3**).

(i) Establish the flow nets on by drawing flow lines and equipotential lines (Follow all the rules in drawing flow nets).

(ii). Determine the total volume of water, **q** flowing under the piling per unit time per unit length in m^3/s. Given that coefficient of permeability of the soil, $k=1.5\times10^{-5}$ m/s.

(iii). Calculate effective stress at **Point A**.

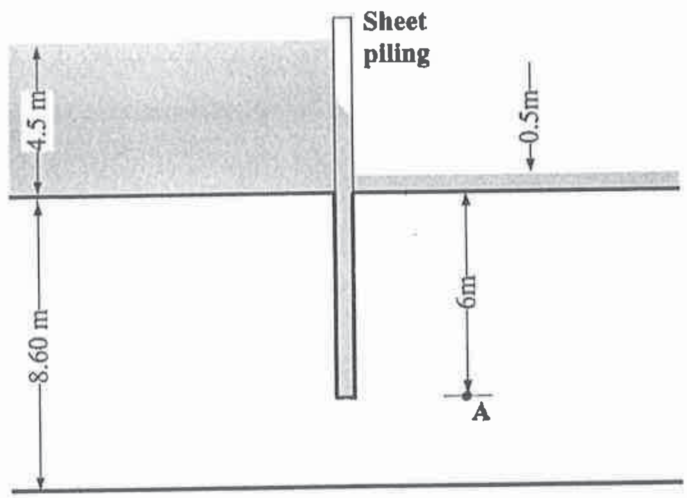


Figure 3

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

(i) What are common assumptions and limitations of elastic theories? Draw the typical variation of vertical stress with depth and variation of vertical stress with horizontal distance at three different depths due to a point load.

(ii) A vertical stress of 100 kPa intensity is applied on the foundation of a structure. The foundation plan of the structure is shown in **Figure 4.** Determine the vertical stress increase at a depth of 4 m below the point 'A' using the Newmark's Chart.

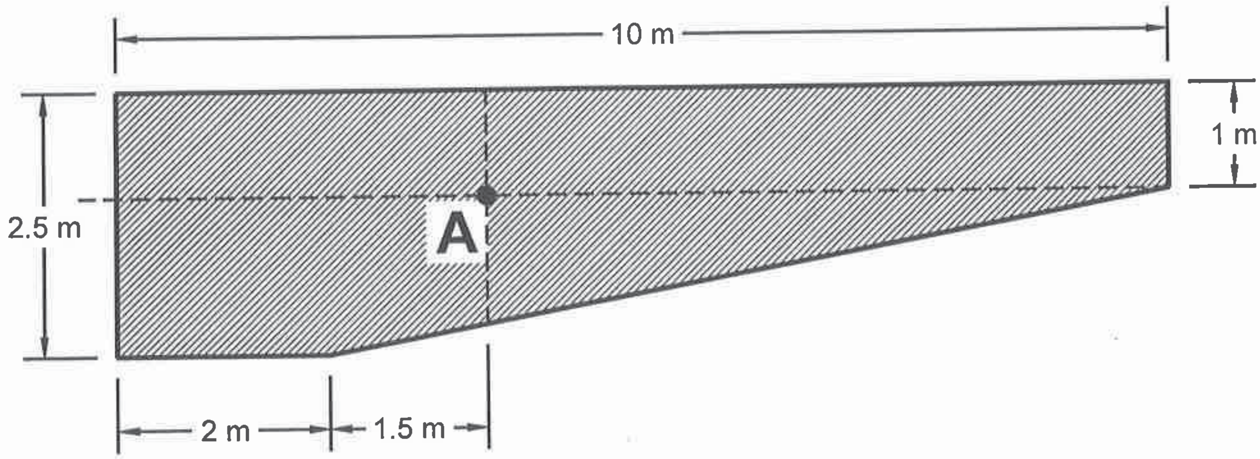


Figure 4

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**.

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 long 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 details about the information that is missing.

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

A soil profile is shown in **Figure 5**. The uniformly distributed load on the ground surface is $\Delta\sigma = 200$ kN/m^2. In the shown soil profile $H_1 = 2$ m, $H_2 = 2$ m, and $H_3 = 4$ m. For sand, $\gamma_{dry} = 14.6$ kN/m^3, $\gamma_{sat} = 17.3$ kN/m^3 and for clay, $\gamma_{sat} = 19.3$ kN/m^3. The Liquid limit, LL = 50%, specific gravity of clay is 2.7 and void ratio = 0.9. Estimate the primary settlement of the normally consolidated clay layer.

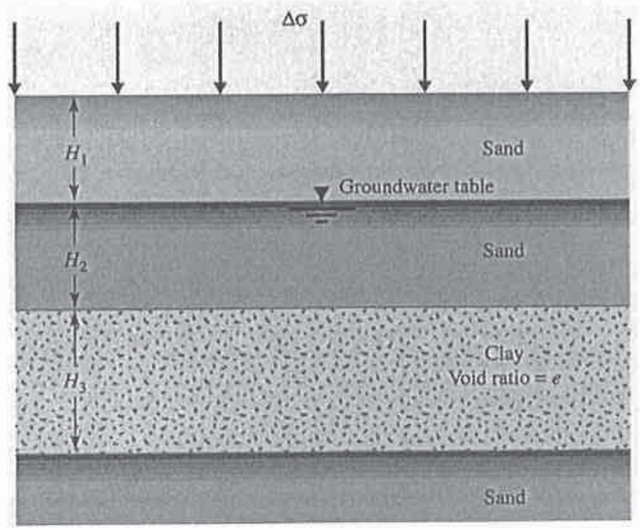
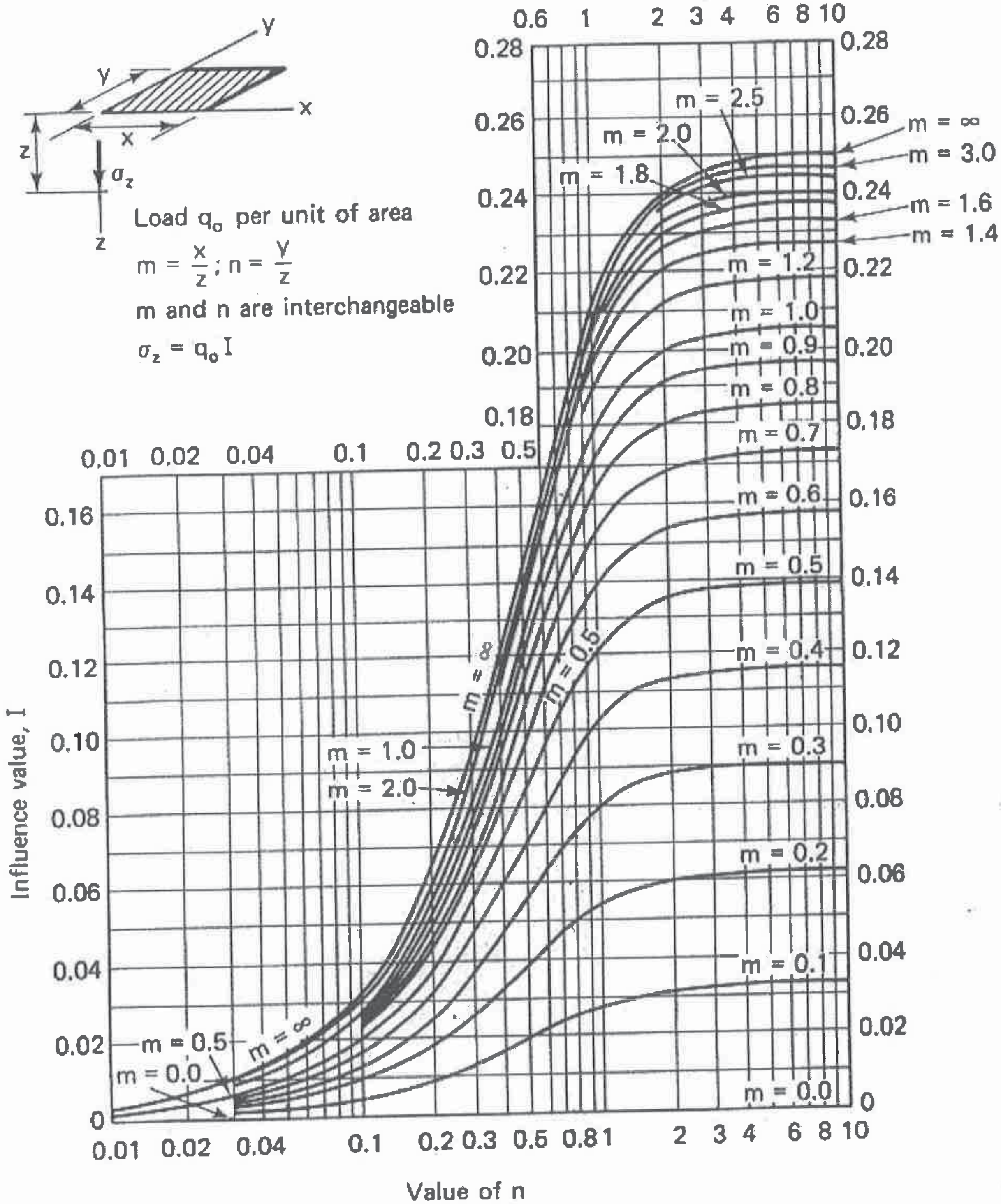
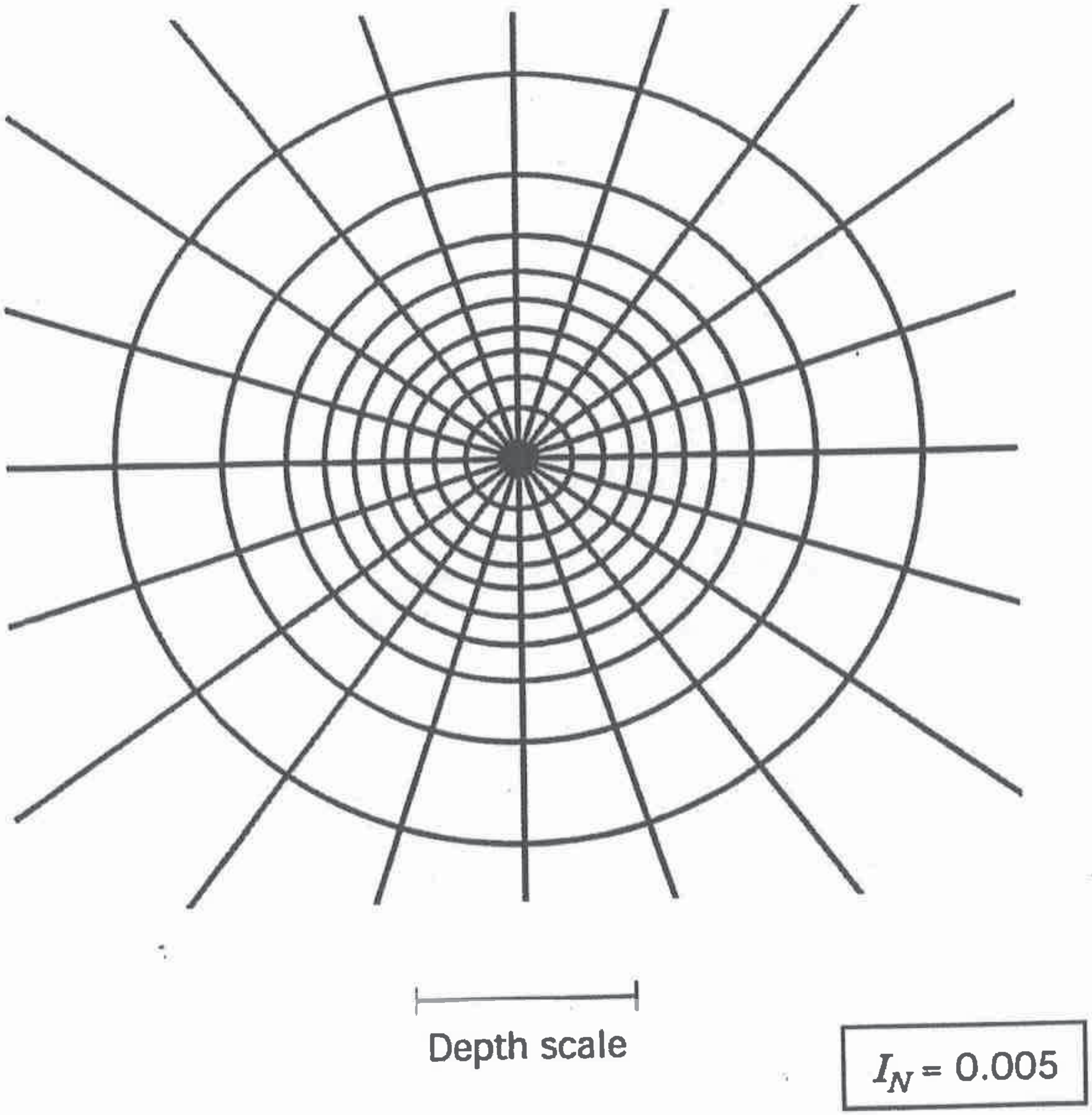

Δσ
H_1
Sand
Groundwater table
H_2
Sand
H_3
Clay
Void ratio = e
Sand

Figure 5


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

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

$\sigma = \gamma D$

$P = \sum N' + uA$

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

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

$\sigma' = \sigma - u$

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

$\frac{\Delta e}{\Delta H} = \frac{1+e_o}{H_o}$; $s_c = H\frac{C_c}{1+e_o}\log\frac{\sigma'_1}{\sigma'_o}$; $s_c = \mu s_{od}$; $m_v = \frac{\Delta e}{1+e}\left(\frac{1}{\Delta\sigma'}\right) = \frac{1}{1+e_o}\left(\frac{e_o - e_1}{\sigma'_1 - \sigma'_0}\right)$

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

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