PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS December 2016
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 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.

NATIONAL EXAMINATIONS –December 2016

98-CIV-A4 GEOTECHNICAL MATERIALS AND ANALYSIS

ANSWER ALL QUESTIONS

Question 1: **(4 x 5 = 20 marks)**

State the correct answer for each of the questions below and provide reasons to **JUSTIFY THE STATEMENT IN YOUR ANSWER BOOK**. You will NOT receive any marks unless you provide your justification.

(i)	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.
(ii)	 A) Flocculated B) Dispersed Oriented **Figure 1** A compacted fine-grained soil will typically have either a flocculated or dispersed structure as shown in **Figure 1**, based on the initial water content used for compaction. What type of soil structure will be created in fine-grained clay when it is compacted wet of optimum water content conditions? Also, discuss about it's coefficient of permeability when the soil is compacted at dry of optimum water content conditions.
(iii)	Which one of the soils **(a)** GW; **(b)** CH will typically have a higher coefficient of permeability? Give reasons.
(iv)	Which one of the following sandy soils; **Sand A** with coefficient of uniformity, C_u = 4 or **Sand B** with C_u = 1 would have a greater coefficient of permeability and greater effective angle of internal friction, ϕ'.
(v)	Which one of the following soils would have a higher angle of internal friction under undrained loading (i.e. ϕ_u) determined from triaxial shear tests: **Soil A:** Expansive clay; **Soil B:** Glacial till; **Soil C:** Silt; **Soil D:** Sand; all soils will have the same value of ϕ_u.

Question 2: **(20 marks)**

For the concrete dam section with two cutoff walls shown in **Figure** 2, construct the flow net. In addition, determine the seepage loss in m^3/day of dam.

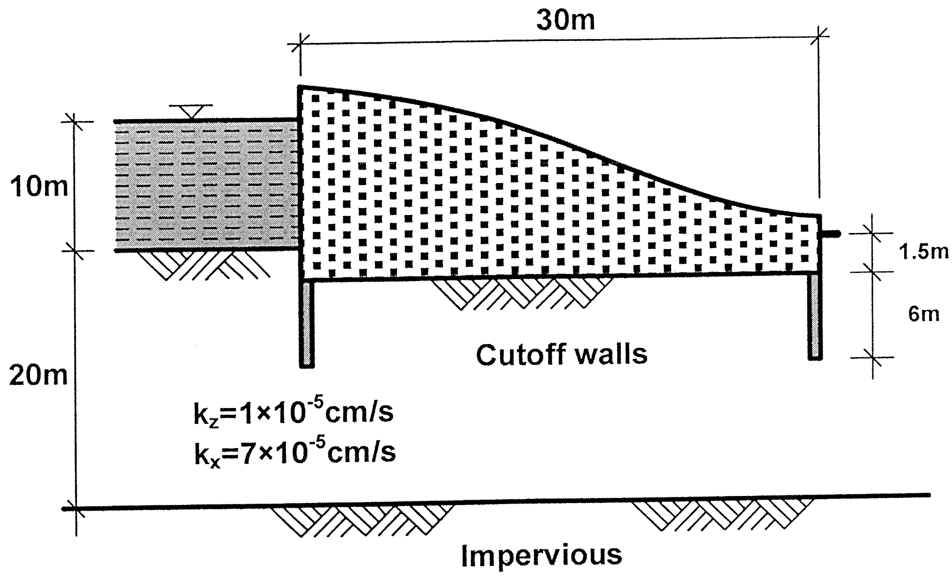


Figure 2

Question 3: **(Value: 20 marks)**

For the foundation shown in in **Figure 3** (shaded area only) which is loaded to a uniform intensity of 200 kPa, determine the increase in vertical stress that occurs at a depth of 2.0 m below points ***A*** and ***B*** using Newmark's chart. Comment on the stress values that you can expect at 4 m depth level at A and B without any calcuations. Discuss the results.

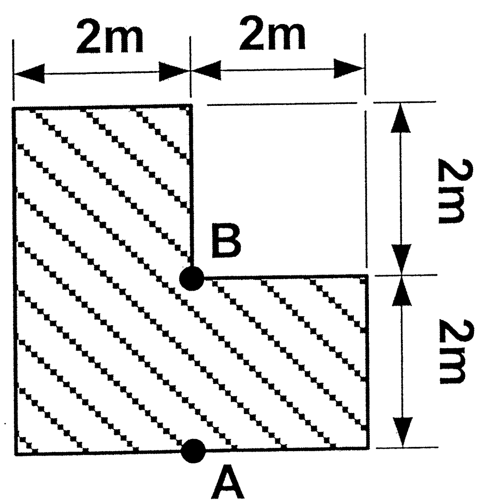


Figure 3

Question 4: (Value: 20 marks)

Assume that the void ratio variation with respect to pressure relationship shown in **Figure 4(a)** is representative of the clay shown in **Figure 4(b)**, determine the settlement under the centre of the footing. Assume, specific gravity $G = 2.7$.

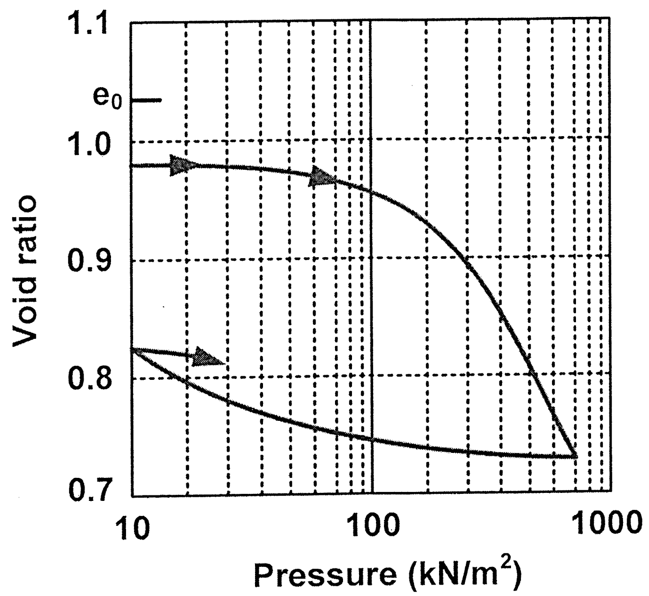


Figure 4(a)

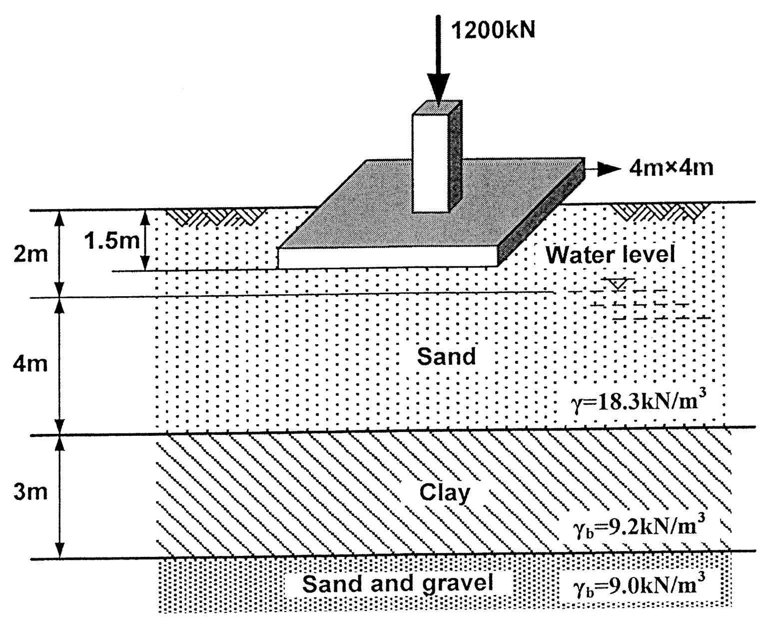
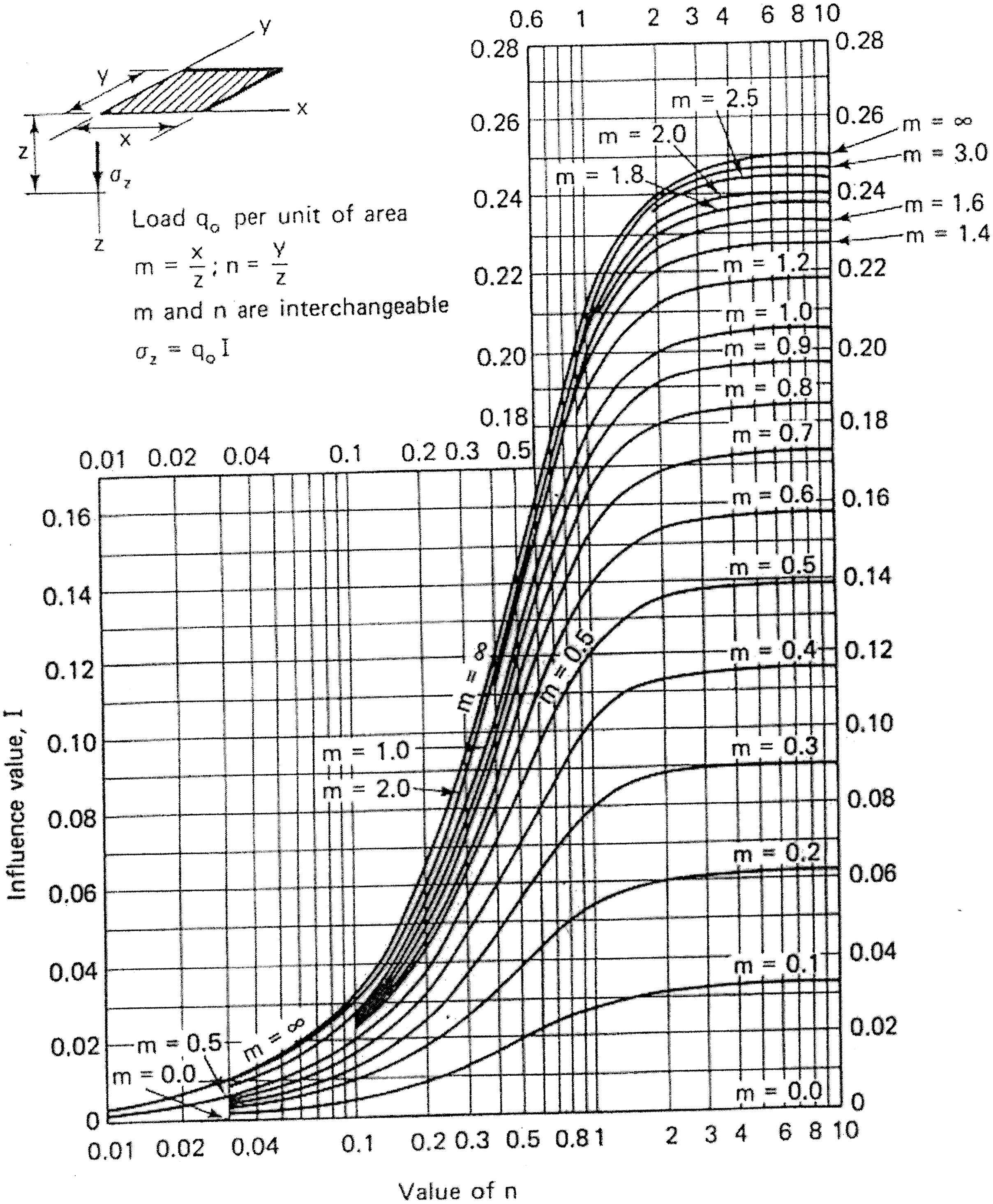


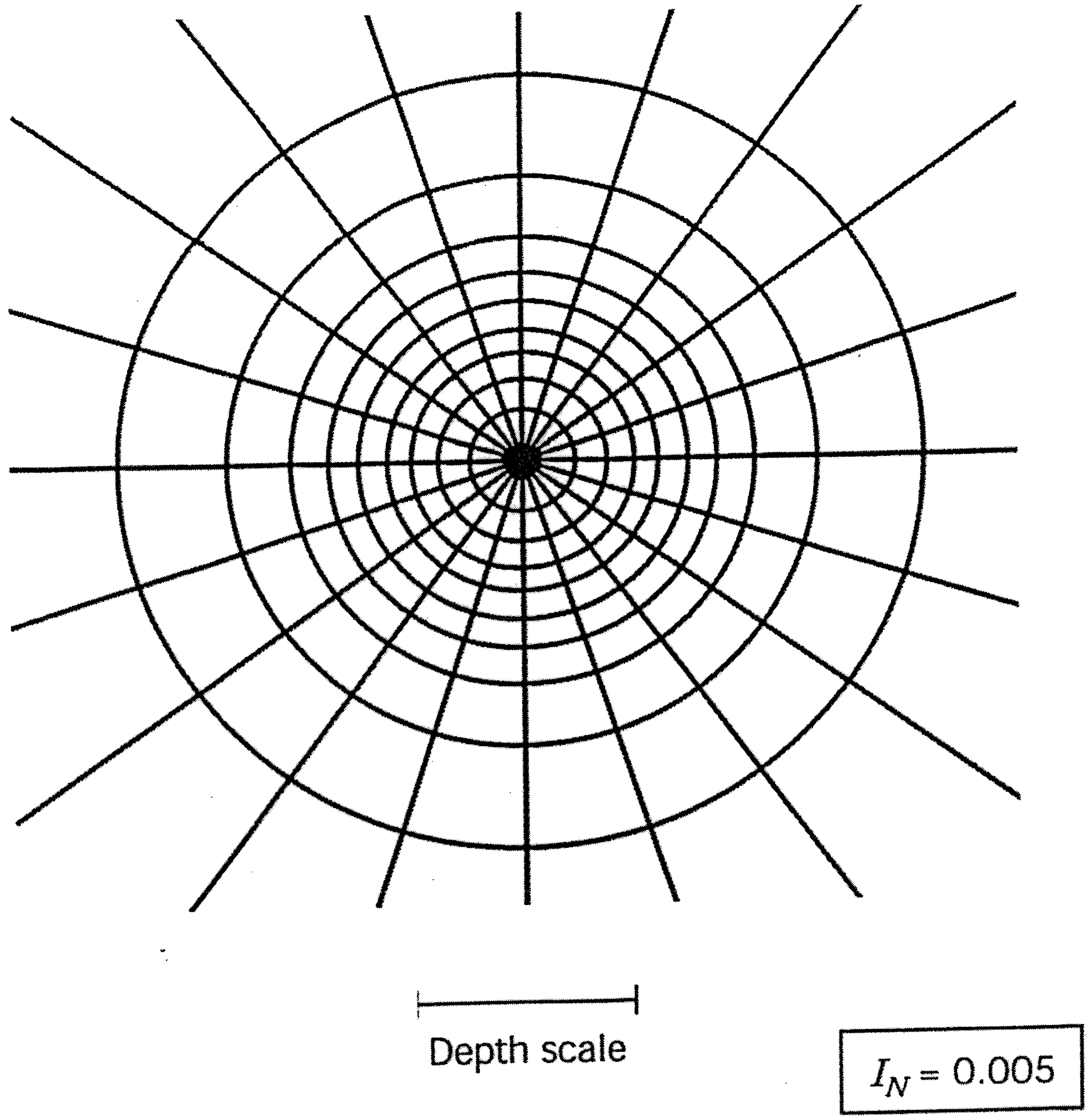
Figure 4(b)

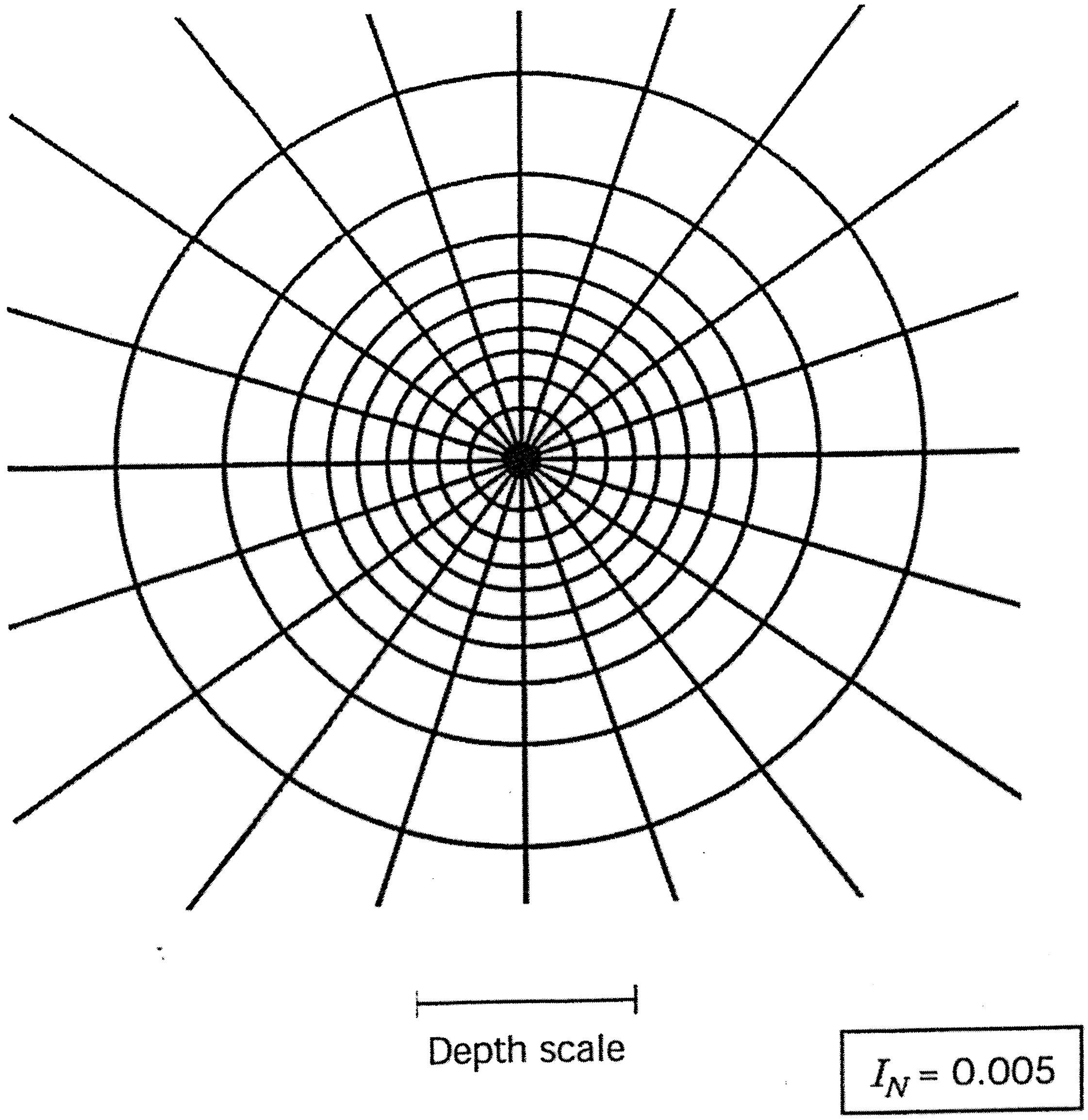
Question 5: **(Value: 20 marks)**

A silty sand specimen's shear strength was found to be equal to 25 kPa when it was tested in a direct shear apparatus under drained loading conditions without application of any normal load. An identical specimen was then subjected a normal stress of 200 kPa, which failed at 130 kPa. Determine the following:

(a) The angle of friction ?
(b) Magnitude of the principal stresses at failure under the normal stress of 200kPa.
(c) The normal and shear stresses the failure plane.


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
$I_N = 0.005$


Depth scale
$I_N = 0.005$

Formula Sheet

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

$\sigma = \gamma D$

$P = \sum N' + uA$

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

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

$\sigma' = \sigma - u$

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

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

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

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: $\sigma_z = 0.005 N q$

$\tau_f = c' + (\sigma - u_w)\tan\phi'$; $\qquad \sigma_1' = \sigma'_3 \tan^2\left(45^o + \frac{\phi'}{2}\right) + 2c' \tan\left(45^o + \frac{\phi'}{2}\right)$

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

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

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

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

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

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