# PROFESSIONAL ENGINEERS ONTARIO
# NATIONAL EXAMINATIONS –May 2016
# 98-CIV-A4 GEOTECHNICAL MATERIALS AND ANALYSIS

## 3 HOURS DURATION

NOTES:

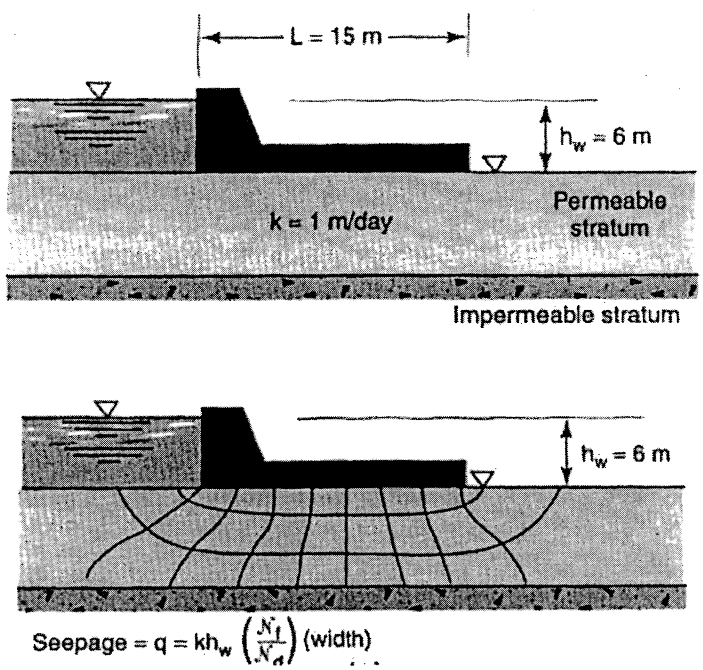
1. This is a **closed book** examination.
2. Read all questions carefully before you answer
3. Should you have any doubt regarding the interpretation of a question, you are encouraged to complete the question submitting a clear statement of your assumptions.
4. The total exam value is 100 marks
5. One 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 –May 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**.

<table>
<tr><td>(i)</td><td>A uniformly graded soil has a good and equal representation of all particle sizes from the largest to smallest size of that particular group</td><td>T</td><td>F</td></tr>
<tr><td>(ii)</td><td><br>Figure 1<br>The seepage below the dam using the flow net and the other information shown in Figure 1 is equal to 3 $m^3$/day per m width.</td><td>T</td><td>F</td></tr>
<tr><td>(iii)</td><td>The pore-water pressure in an over consolidated clay is negative when it is subjected to a loading that is less than its preconsolidation pressure.</td><td>T</td><td>F</td></tr>
<tr><td>(iv)</td><td>The degree of saturation of both compacted sand and clay specimen at optimum moisture content is always lower than 100%.</td><td>T</td><td>F</td></tr>
<tr><td>(v)</td><td>Both the triaxial test and the direct shear test equipment can be used to determine the effective shear strength parameters ($c'$ and $\phi'$) of sands and as well as clays under drained loading conditions (i.e. CD tests).</td><td>T</td><td>F</td></tr>
</table>

**Question 2:** **(10 marks)**

Briefly explain the three different "limit" lateral earth pressures (i.e., at-rest, active, and passive conditions) that can act on a retaining wall. Also, show the Mohr circle for each condition (Note: You are expected to draw simple sketches of retaining walls and Mohr failure envelopes for the three cases; **Figure 2** is shown below as an example without providing the key details).

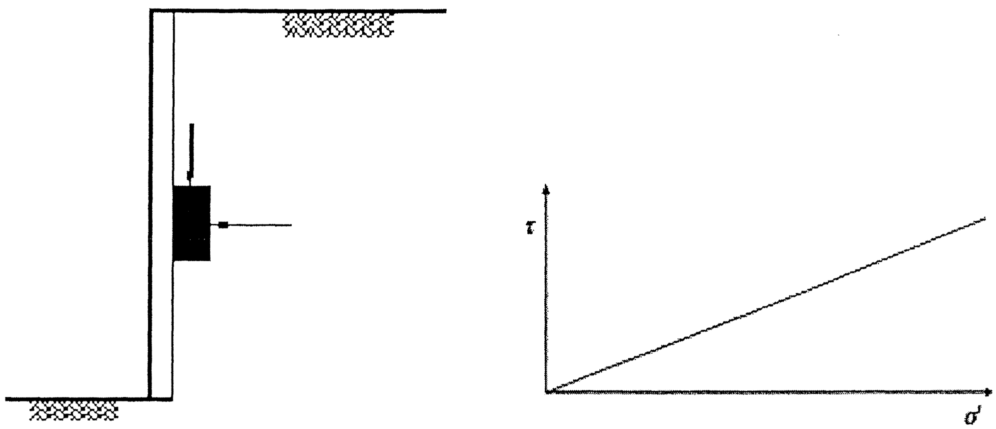



**Figure 2**

**Question 3:** **(10 marks)**

As a junior engineer, you are asked to estimate the settlement that would arise due to the construction of a structure on a soil that predominantly has organic material such as peat. What test or tests do you undertake? What are the key properties or parameters would you derived from these tests. Also, how would you proceed with your analysis for estimating the settlement?

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

**Figure 3** shows the plan view of a 5 story condominium structure. Determine the increase in vertical stress $\Delta\sigma_z$ due to the load, at depths of **2 and 5 m** vertically below **point A** (Use superposition method). Comment on the stress values determined at different depths and how this information is useful for a geotechnical engineer. The load on foundation of the building (shaded area) will be approximately equal to 10 kPa per story.

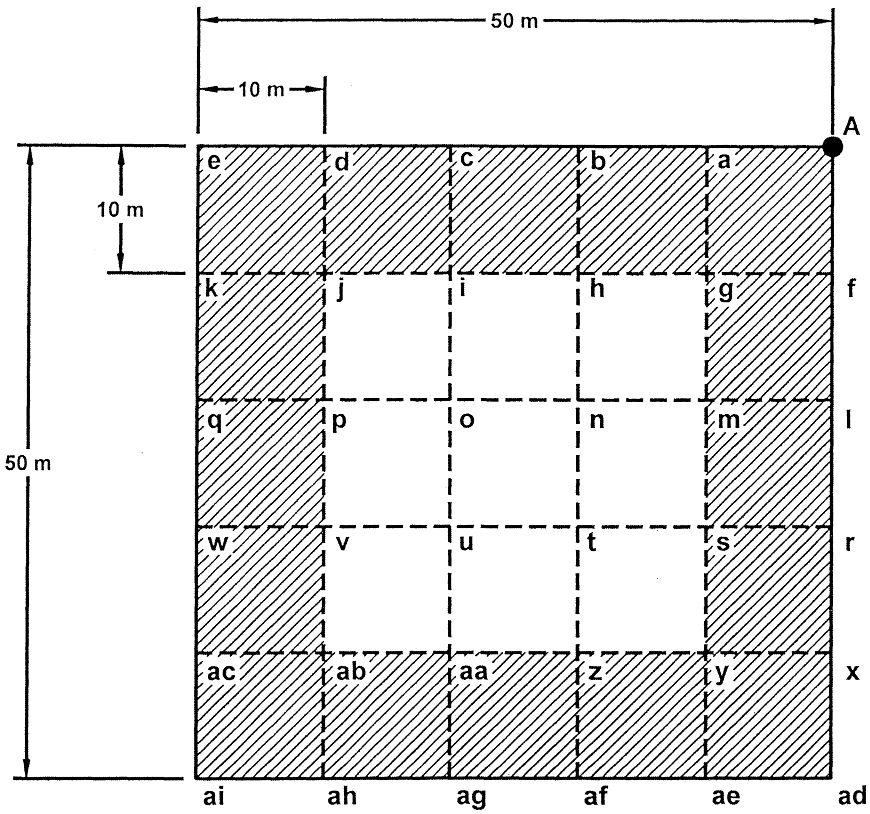



**Figure 3**

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

For a cutoff wall shown in **Figure 4**

**a.** Establish the **flow nets** (i.e. flow and equipotential lines) following all the rules (draw on Figure 4). **(10 marks)**

**b.** Calculate the **effective stress** at point **A** (back of the piling) ($\gamma_{sat} = 20$ kN/m$^3$). **(10 marks)**

---

Effective stress ( $\sigma'$ ) = Total stress ( $\sigma$ ) – Pore water pressure ( $u$ )

$u = (h - z)\gamma_w$

---

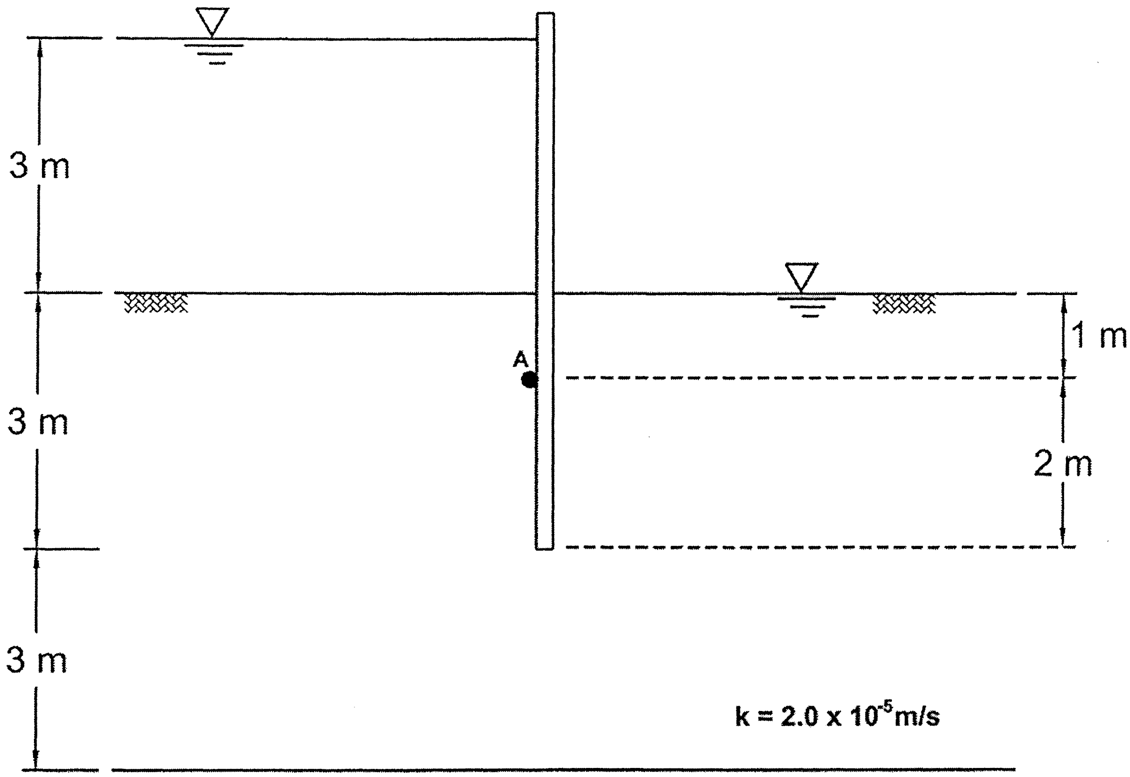


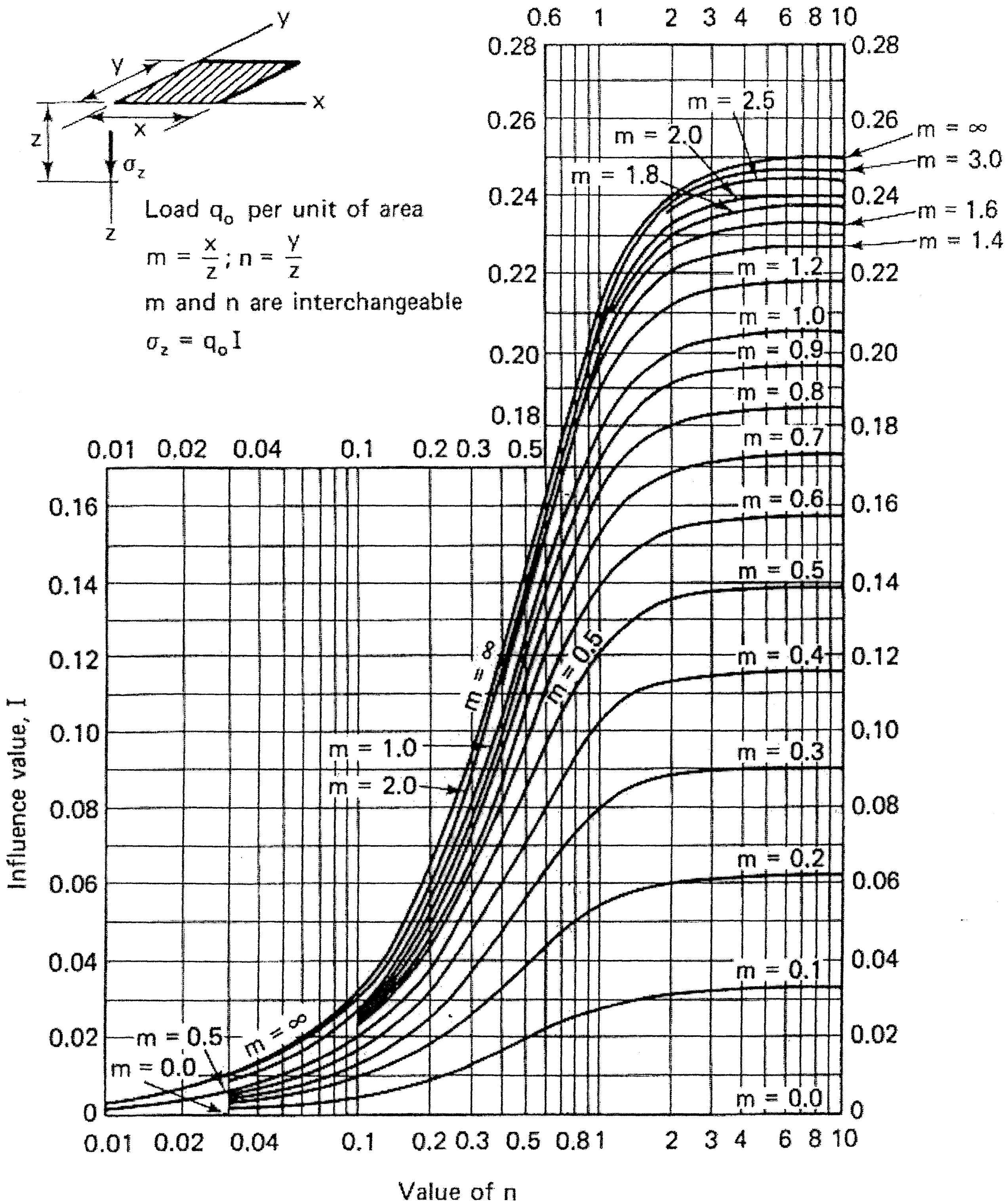

**Figure 4**

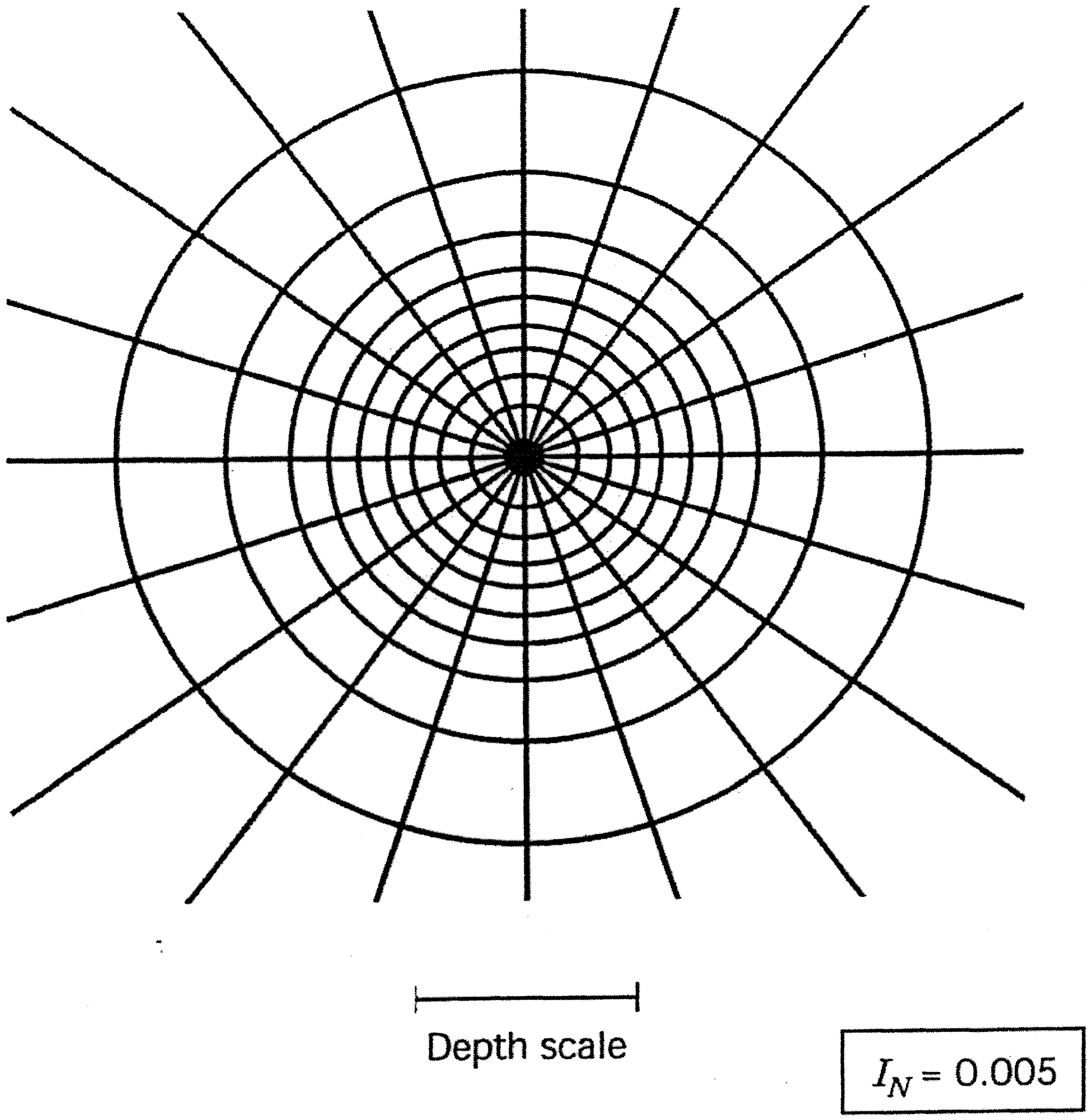
**Question 6:** **(Value: 20 marks)**

A series of drained triaxial tests was carried out on specimens of a sand prepared at the same porosity and the following results were obtained at failure.

| | | | | |
|---|---|---|---|---|
| All-round pressure (kN/m$^2$) | 100 | 200 | 400 | 800 |
| Principal stress difference (kN/m$^2$) | 452 | 908 | 1810 | 3624 |

Determine the value of the angle of shearing resistance $\phi'$ analytically and also draw the Mohr circles to verify your result.


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

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

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

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

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

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