# Addis Ababa University
# Addis Ababa Institute of Technology
# School of Civil & Environmental Engineering

## Fundamentals of Geotechnical Engineering III (CEng3143)
## Test 1 Question Paper Set

| | |
|---|---|
| Name | |
| ID No. | |
| Signature | |
| Section | |
| Exam Date: | 04.11.2019 |

Instruction:

1) This test is closed book and constitutes 10% of your final grade.
2) The time allowed for this test is 1 hour.
3) Please read the questions carefully and make sure you understand the facts before you begin answering. Write as legibly and concisely as possible.
4) Use the provided space properly to present you answer.
5) For all problems, assume Gs=2.7 unless stated otherwise.

| Question # | Weight [marks] | Score [marks] |
|---|---|---|
| 1 | 20 | |
| 2 | 40 | |
| 3 | 40 | |
| | | |

Checked by: Asrat Worku (Dr.-Ing.)

Signature:

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## QUESTION 1: Theoretical Background [20%]

1.1 What is the difference between consolidation and compaction?

1.2 A clay soil is 80% saturated. Would Terzaghi's consolidation theory be applicable to this soil? Justify your answer.

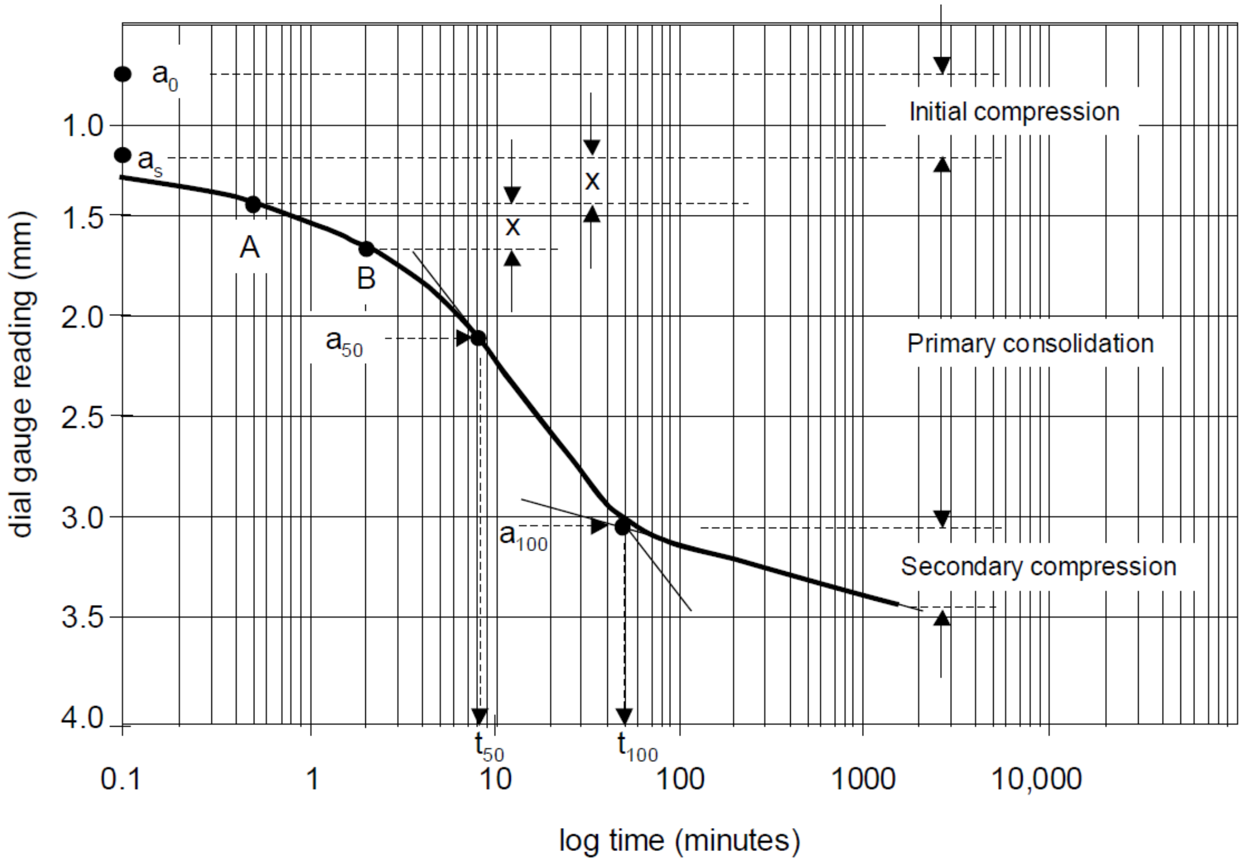
1.3 In the development of one-dimensional consolidation theory, small strains are assumed (i.e. the strains, change in length divided by original length in a given direction, are infinitesimal ≈ < 0.001% for practical applications). What is the implication of this assumption?

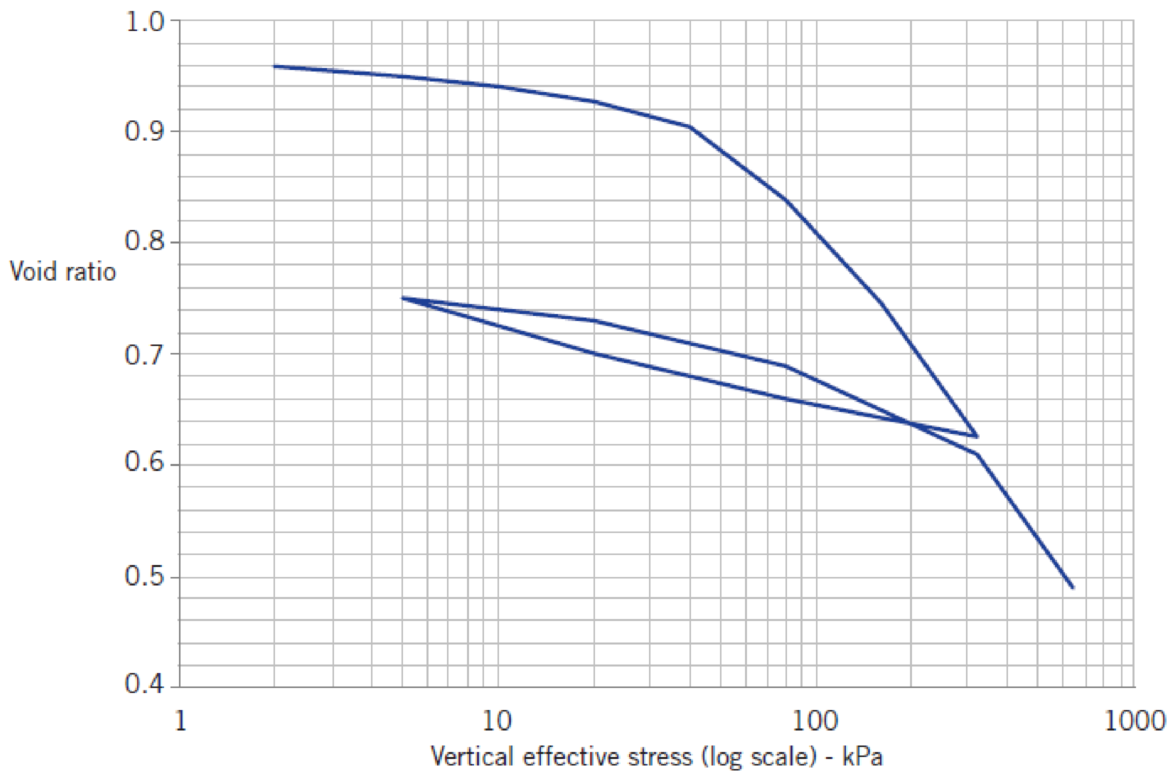
1.4 The one-dimensional consolidation equation allows us to predict the changes in excess porewater pressure at various depths within the soil with time. What is excess pore pressure (in the context of oedometer testing) and why do we need to know it for the calculation of consolidation in soils?

1.5 How much mass do you have to mount onto the consolidometer at AAiT geotechnical engineering laboratory if you want to apply a pressure of 100kpa on the specimen?

## QUESTION 2: Oedometer Testing & Interpretation [40%]

The results of a one-dimensional consolidation test on a clay taken from a depth of 4m are shown in Figure 2.1. The initial overburden (effective) pressure was 40kPa. The water content after the consolidation test was completed was 18.9%. The specific gravity of the solids was 2.65. The initial sample thickness was 20 mm. and the final thickness was 15.08mm.



Determine the parameters required for calculation of elastic compression, primary consolidation and secondary consolidation (secondary compression).

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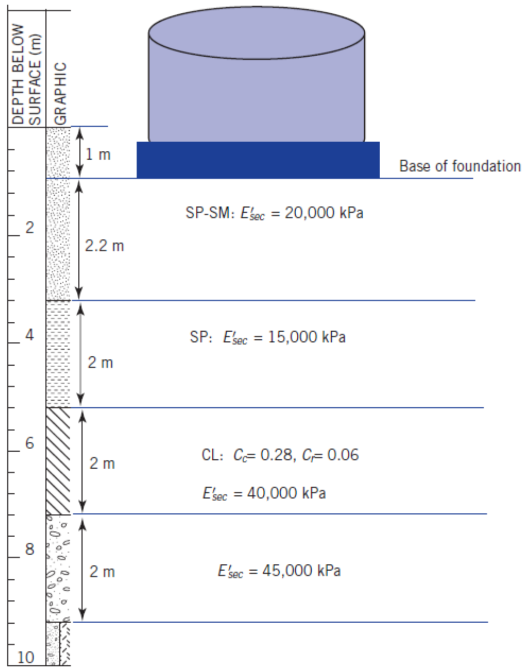
|---|---|
| Initial void ratio, $e_o$ | |
| Compression index, $C_c$ | |
| Recompression index, $C_r$ | |
| Pre-consolidation pressure, $P_c$ | |
| Overconsolidation ratio, OCR | |
| Coefficient of consolidation, $C_v$ (in $cm^2/sec$) (Hint: use the Log Time Method) | |
| Modulus of volume re-compressibility | |
| Constrained elastic modulus, | |
| Time for primary consolidation, $t_p$ | |
| Secondary compression index, $C_\alpha$ | |

# QUESTION 3: Settlement Computation [40%]

A representative stratigraphy at a site for a proposed grain storage tank, 4m in diameter and 15m high, is shown in Figure 3.1. The groundwater is at the top of the clay layer. The tank is located on a circular concrete slab 5m in diameter that serves as the foundation transmitting the loads to the soil. The weight of the tank full to capacity and of the concrete foundation is 3200kN. Local code regulations require that the minimum depth of embedment of the foundation be 1m from the finished surface elevation.

| Soil Layer | Estimated Young's moduli $E'_{sec}$ |
|---|---|
| Poorly graded sand with silt (SP-SM) | 20,000kPa |
| Poorly graded sand (SP) | 15,000kPa |
| Lean clay (CL) | 40,000kPa |
| well-graded gravel with sand (GW) | 45,000kPa |




The specific gravity of clay is 2.65. Assume ν′= 0.35 and neglect the effects (e.g., uplift) of soil excavation.

One-dimensional consolidation test on the clay (CL) gave Cc = 0.28, Cr = 0.06, Cv =0.05 $m^2$/day and OCR = 8

3.1 Calculate the settlement due to the storage tank. (You may follow the following steps)

a) Estimate the elastic settlement of each layer except the GW soil layer.
b) Estimate the primary consolidation of the clay layer.
c) Compute the total settlement.

3.2 Estimate how long it would take for 50%, 90% and 100% of primary consolidation settlement in the clay to occur.

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|---|---|
| $S_i = \frac{q_s D(1-v^2)}{E'} I_d$<br>Where $q_s$ uniform surface stress, D is the diameter of the loaded area | Center of the circular area: $I_d = 1$<br>Edge of circular area: $I_d = \frac{2}{\pi}$ |
| NC Clay<br>$S_c = C_c \frac{H_o}{1+e_o} log \frac{\sigma'_{zo} + \Delta\sigma_z}{\sigma'_{zo}}$ | $C_c = -\frac{e_2 - e_1}{log\frac{(\sigma'_z)_2}{(\sigma'_z)_1}}$ |
| OC Clay<br>If $\sigma'_{zo} + \Delta\sigma_z < \sigma'_{zc}$ ,<br>$S_c = C_r \frac{H_o}{1+e_o} log \frac{\sigma'_{zo} + \Delta\sigma_z}{\sigma'_{zo}}$<br>If $\sigma'_{zo} + \Delta\sigma_z > \sigma'_{zc}$ ,<br>$S_c = \frac{H_o}{1+e_o}\left(C_r \log\frac{\sigma'_{zc}}{\sigma'_{zo}} + C_c \log\frac{\sigma'_{zo} + \Delta\sigma_z}{\sigma'_{zc}}\right)$ | $m_v = -\frac{(\varepsilon_z)_2 - (\varepsilon_z)_1}{(\sigma'_z)_2 - (\sigma'_z)_1}$<br>$C_r = -\frac{e_2 - e_1}{log\frac{(\sigma'_z)_2}{(\sigma'_z)_1}}$<br>$m_{vr} = -\frac{(\varepsilon_z)_2 - (\varepsilon_z)_1}{(\sigma'_z)_2 - (\sigma'_z)_1}$ |
| $S_s = \frac{H_o}{1+e_o} C_\alpha \log\left(\frac{t}{t_p}\right)$ | $C_\alpha = -\frac{(e_t - e_p)}{log(t/t_p)} = \frac{\lvert\Delta e\rvert}{log(t/t_p)}; t > t_p$<br>$C_\alpha/C_c = 0.03 \; to \; 0.08$ |
| $T_v = \frac{\pi}{4}\left(\frac{U}{100}\right)^2 \; for \; U < 60\%$<br>$T_v = 1.781 - 0.933 \log(100 - U) \; for \; U \geq 60\%$ | $T_v = \frac{C_v t}{H_{dr}^2}$ ; $C_v = \frac{k_z}{m_v \gamma_w}$ |
| Stress increase under the center of circular loading $\Delta\sigma_v = q\left[1 - \frac{1}{\left[\left(\frac{R}{z}\right)^2 + 1\right]^{3/2}}\right]$ | |