

Exam Soil Mechanics

Bachelor 2nd year, CiT/CTW

Module/course code: 202000065-1A: Safety and Risk in Delta's – Soil Mechanics

Date: 09 November 2023

Time: 13.45-15.45 (+25% for students who may use extra time)

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Instructors: Hongyang Cheng and Floriana Anselmucci

Type of test: Exercises, Open questions.

Allowed aids: Scientific calculator, formula sheet, English-Dutch dictionary.

Attachments: Formula sheet.

Exercise 1

A soil sample of saturated clay with a specific weight $\gamma_{\text{sat}} = 25 \text{ kN/m}^3$ was extracted for laboratory testing. A Consolidated Undrained triaxial test was performed on such sample with an isotropic chamber pressure of $\sigma_3 = 20 \text{ kPa}$. From the test, the effective friction angle and effective cohesion are obtained: $\phi' = 24^\circ$ and $c' = 8 \text{ kPa}$.

At failure the pore pressure recorded is $u = 18 \text{ kPa}$, the principal stresses difference $\Delta\sigma = 28 \text{ kPa}$, and the failure occurs on a plane inclined at $\theta = 57^\circ$.

- 1.1 Calculate the shear stress τ on the failure surface;
- 1.2 Calculate the normal stress σ on the failure surface;
- 1.3 Calculate the maximum shear stress on the specimen;
- 1.4 Prove numerically why the sample does not fail on the plain of maximum shear stress but on a plain inclined of 57° .
- 1.5 Briefly explain the outcome of the previous point.

Exercise 2

A new building is planned on a site with the following soil stratigraphy: a sand layer of 15m on top of a 6m layer of clay. The building will induce a surcharge $\Delta\sigma = 100 \text{ kPa}$ on the soil. The water table is placed at 8m from the top surface (i.e., the sand layer has only 7 meters in saturated conditions, and the clay layer is fully saturated). Assume a specific gravity of 2.67 for the clay.

The properties of the sand are $\gamma_{\text{dry}}^{\text{sand}} = 15 \frac{\text{kN}}{\text{m}^3}$; $\gamma_{\text{sat}}^{\text{sand}} = 19 \frac{\text{kN}}{\text{m}^3}$

The properties of the clay are $w = 34\%$, $LL = 50\%$, $\gamma_{\text{sat}}^{\text{clay}} = 21 \frac{\text{kN}}{\text{m}^3}$

- 2.1 Sketch the stratigraphy explained above
- 2.2 Calculate the compression and recompression index knowing that:

$$C_c = 0.009(LL\% - 10); C_e = 0.15C_c$$

- 2.3 Find the settlement of the clay layer when it is normally consolidated;
- 2.4 Find the settlement of the clay layer when $OCR=3$;
- 2.5 Calculate what would be the settlement if $\sigma'_{max} = 400\text{kPa}$?
- 2.6 Compare the three different cases in a $e-\log(\sigma')$ graph;
- 2.7 Which of the 3 cases is safest condition for the new building? Justify your answer.

Exercise 3

Two water basins are connected by a permeable layer confined between two impermeable layers. The geometry and hydraulic properties of the layers are schematized in the figure. Determine, under steady-state conditions:

- 3.1 the hydraulic gradient of the filtration motion;
- 3.2 the equivalent permeability of the 3 permeable layers;
- 3.3 the flow rate of the motion.

