GEOMECHANICS
DR. A. FERRARI AND PROF. L. LALOUI

Project – Part 1 – 02.10.2025 (**due on 19.12.2025**)

Evaluation and design of a geotechnical project using finite element method

Problem statement

As a geotechnical engineer, you are tasked with conducting a detailed assessment of the soil conditions for an upcoming geotechnical project. The assessment includes a series of triaxial tests that were done on samples taken from soil cores extracted on site. You will analyse the results provided by the lab and determine the key soil parameters necessary for the design process. The data and parameters you establish at this phase will be critical for the geotechnical design in subsequent phases of the project.

1. Analysis of experimental data

Drained conventional triaxial tests (CTC) were conducted to study the behaviour of the saturated clay on site. The samples were first subjected to an initial effective preconsolidation of $50\ kPa$ after which the bulk density of the samples was measured at $\gamma = 19\ kN/m^3$, their water content as $w = 36\ \%$, and their void ratio was $e = 1.0$. The porewater pressure p_w was kept equal to 100 kPa during all stages of the tests.

The specimens were then placed in a triaxial cell where they were isotopically compressed (isotropic compression stage) to three different initial pressures: $p'_{initial} = 50,\ 200,\ 400\ kPa$, the void ratio and the dimensions at each of these initial pressures are reported in Table 1.

Test	$p'_{initial}\ [kPa]$	$e_0\ [-]$	D_0 [mm]	H_0 [mm]
1	50	1.0	38	76
2	200	0.67	38	76
3	400	0.53	38	76

Table 1 – Test initial conditions. p'_{initial} isotropic compression pressure, e_0 = void ratio, D_0 = diameter, and H_0 = height at the end of the isotropic compression

Following the isotropic compression, drained shearing was conducted up to an axial strain of 25%. The results from the shearing stage of all three CTC tests are reported in the Excel file "***Experimental results.xslx***".

The results show the changes in the applied force F, the axial displacement δ (negative means that the sample height is reducing), and the porewater volume variation during the test ΔV_w (positive ΔV_w implies that water flows out of the sample).

Tasks:

1. Calculate deviatoric stress *q*, mean effective *p'* and total *p* stress, axial and radial strain ε_a, ε_r, and volumetric strain ε_v for each step of the test and give the values in a table. Then, plot the experimental results in the following planes (y-axis - x-axis):

2. Plot the data in the $q - p'$, $q - p$ and comment on the observed trends.

3. Plot the test results in the $q - \varepsilon_a$, ε_v - ε_a and derive the elastic parameters E_0 and ν_0 and E_{50} and ν_{50} for all three tests, as well as E_{ur} and ν_{ur} for the third test. Using the values obtained for E_{50} and

ν_{50} compute the resulting shear and bulk moduli. (The definitions of initial tangent and secant parameters are provided in Figure 1.)

4. Plot the test results in the $q - \varepsilon_d$, $\boldsymbol{\varepsilon}_v - \boldsymbol{\varepsilon}_d$ and derive the elastic parameters G_{50} and K_{50} for all three tests. Compare the obtained values with those calculated in question 3 and comment on the results

5. Plot the stiffness parameters E_{50} and ν_{50} with the confining stress and comment on the observed trends.

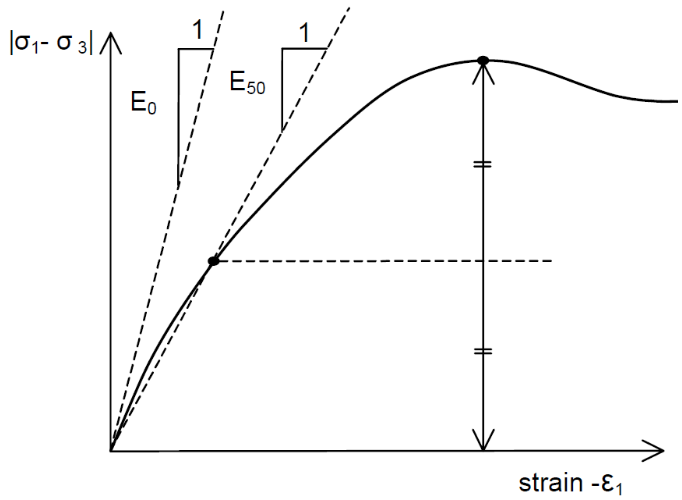

Figure 1 - Definition of the initial tangent Young's modulus (E_0) and the secant Young's modulus at 50% of the maximum deviatoric stress (E_{50})