

EXERCISE 1

In order to determine the shear strength parameters of a soil, a direct shear test will be conducted. This soil has been named as SP, poorly graded sand, according to the USCS.

Three tests have been completed, providing the maximum (peak) and ultimate shear stress values:

Test 1. $\tau_p = 39.93$ kPa; $\tau_U = 34.72$ kPa

Test 2. $\tau_p = 78.28$ kPa; $\tau_U = 68.07$ kPa

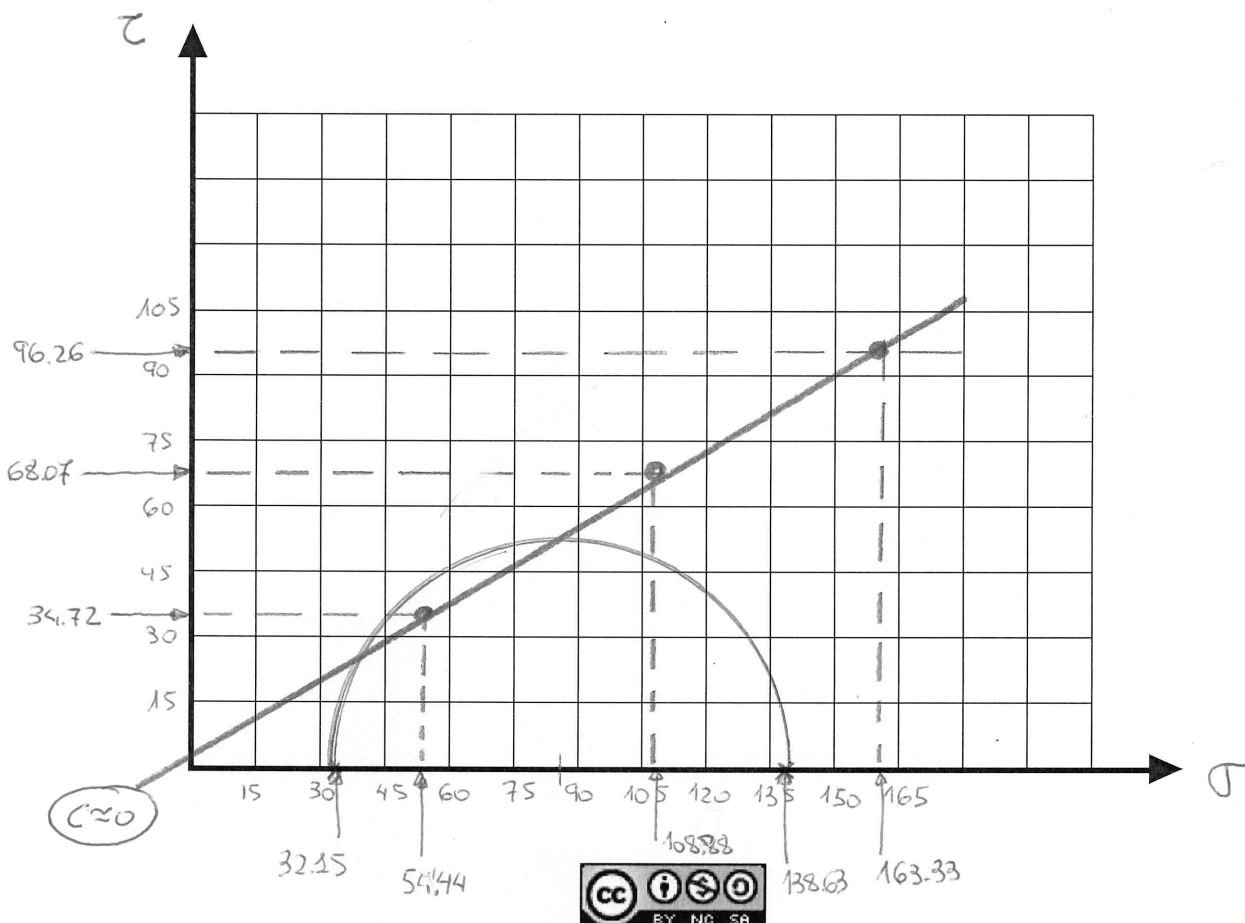
Test 3. $\tau_p = 110.70$ kPa; $\tau_U = 96.26$ kPa

Soil samples were put into a 60-mm square shear box, and the masses used to apply the vertical forces were 20 kg, 40 kg and 60 kg, respectively.

Determine the shear strength parameters of this soil.

On this soil, a construction is to be done that will give rise, at the most dangerous point, to a Mohr's circle having the following principal stresses $\sigma_1 = 138.63$ kPa and $\sigma_3 = 32.15$ kPa. Explain whether the soil will fail.

Answer: $\phi \approx 29.5^\circ$.



Direct shear test is explained in slides 11 to 13 of the lecture material.

First, the shear stress at failure is chosen. Two values are calculated; peak value and ultimate value. As, last one provides smaller strength values, the ultimate shear stress value will be selected.

Therefore,

$$\text{Test 1. } \tau_{f1} = 34.72 \text{ kN/m}^2 \quad \text{Test 2. } \tau_{f2} = 68.07 \text{ kN/m}^2 \quad \text{Test 3. } \tau_{f3} = 96.26 \text{ kN/m}^2$$

In each test, vertical force is applied on the sample by means of some weights.

$$\text{Test 1: } m_1 = 20 \text{ kg} \rightarrow \sigma_{v1} = \frac{m_1 \cdot g}{p^2} = \frac{20 \cdot 9.8}{60^2} = 0.05444 \frac{\text{N}}{\text{mm}^2} = 54.44 \frac{\text{kN}}{\text{m}^2}$$

$$\text{Test 2: } m_2 = 40 \text{ kg} = 2 \cdot m_1 \Rightarrow \sigma_{v2} = 2\sigma_{v1} = 108.88 \text{ kN/m}^2$$

$$\text{Test 3: } m_3 = 60 \text{ kg} = 3 \cdot m_1 \Rightarrow \sigma_{v3} = 3\sigma_{v1} = 163.33 \text{ kN/m}^2$$

Those values corresponding to each test are taken to the chart (see previous page 1.2).

There $c = 0$ (sand is a granular soil and does not have cohesion), and the friction angle, ϕ , can be estimated by using test 1 and test 3, as follows:

$$\underline{\underline{\phi}} \approx \arctan \frac{\tau_{f3} - \tau_{f1}}{\sigma_{v3} - \sigma_{v1}} = \arctan \frac{96.26 - 34.72}{163.33 - 54.44} = 29.48 \approx 29.5^\circ$$

Most dangerous point \rightarrow principal stresses: $\sigma_1 = 138.63 \text{ kN/m}^2$, $\sigma_3 = 32.15 \text{ kN/m}^2$

σ_1 and σ_3 let us to plot the corresponding Mohr circle (see previous page 1.2).

It is shown that Mohr circle "cuts" or intersects the failure line \Leftrightarrow FAILURE occurs

EXERCISE 3

An unconfined compression test has been completed on a saturated cohesive soil. The failure took place when a vertical force $F = 65.3 \text{ N}$ was applied.

The soil sample was cylindrical, having a diameter of 35 mm and a height of 100 mm. Determine the undrained shear strength of that sample in kPa.

Answer: $c_u = 33.94 \text{ kPa}$.

Unconfined compression test is especially interesting in cohesive soils to determine the short-term or undrained strength parameters (c_u), according to slide 20 of the lecture material.

Sample: $D = 35 \text{ mm} \Rightarrow$ cross section area $\equiv A = \frac{\pi}{4} \cdot D^2 = 962.11 \text{ mm}^2$

At failure, a vertical force $F = 65.3 \text{ N}$ was applied.

Then, the unconfined compressive strength is

$$q_u = \frac{F}{A} = \frac{65.3}{962.11} = 67.87 \cdot 10^{-3} \frac{\text{N}}{\text{mm}^2} = 67.87 \text{ kN/m}^2$$

Finally, the undrained shear strength is

$$\underline{c_u} = \frac{q_u}{2} = \underline{\underline{33.94 \text{ kN/m}^2}}$$