The effect of the degree of saturation on shear strength of sandy soils. The example of Geni Tzami of Edessa, Northern Greece

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Introduction/Setting

In order to investigate the foundation’s conditions of a construction, it is important to determine the mechanical characteristics of the subsoil and specifically the determination of its shear strength and compressibility. In cases where sandy soils undergo fluctuations in their moisture content, the determination of their shear strength should take into account their behavior in unsaturated conditions (Fredlund & Rahardjo, 1993). This requires, shear tests of soil specimens (in this case direct shear tests) performed with control of the degree of saturation. The present paper presents the subsoil’s mechanical behavior in the Geni Tzami of Edessa under conventional tests as well as tests in unsaturated conditions. The city of Edessa is located in Almopia which is the western sub-zone of the broader Axios geotectonic zone in Central Macedonia. The Geni Tzami is founded on the Quaternary formations of the city which are mainly aluvial deposits and cones of fluvial deposits from the underlying travertines of Edessa (Figure 1).

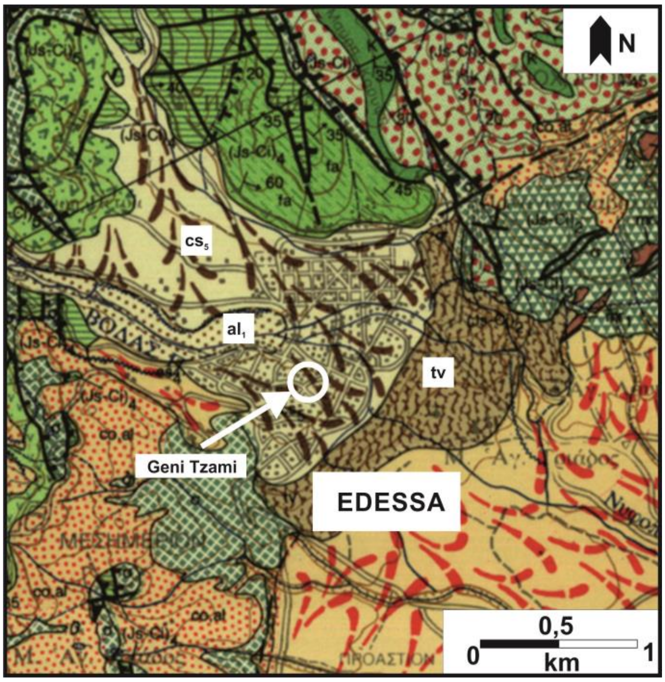

Figure 1. The geology of the city of Edessa (Quaternary): al_1, alluvial deposits cs_5 cones of fluvial deposits, tv: travertines

Methodology

The restoration of Geni Tzami included a core sampling 15m borehole for the geological and geotechnical investigation of the foundation conditions. The results of the coring showed an interchange between sand and silty sand layers with variable fines content and a small percentage of gravels. The groundwater conditions were dry during the drilling but a low potential groundwater table might develop during the wet season in the coarser deposits. The mechanical properties of the soil samples (c' and φ') were estimated using both empirical relationships from the N_{SPT} values and a specific laboratory testing experimental program. Till recently the production of reliable experimental data for the unsaturated behavior of granular soils using the axis translation technique was difficult. This was due to the lack of sophisticated laboratory equipment for non cohesive soils since most of the used devices required cohesive specimens. The device used for this experimental programwas the GDS unsaturated back-pressure shear boxof the Laboratory of Engineering Geology & Hydrogeology of A.U.TH. (Figure 2).Since the foundation soil is mostly under partially saturated conditions the soil specimens were tested for shear strength via consolidated drained shear tests under their natural moisture content and in saturated condition so as to obtain a more accurate picture of the actualin situ shear strength.The unsaturated conditions were simulated using the axis translation technique by applying constant pore-air and pore-water pressure in order to control the matric suction in the samples.

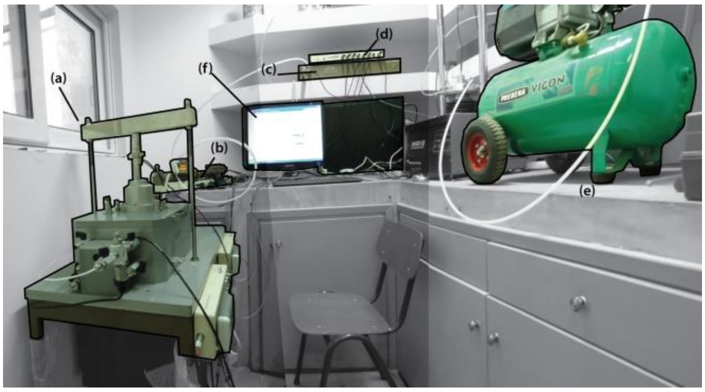

Figure 2. The GDS unsaturated back-pressure shear box of the Laboratory of Engineering Geology & Hydrogeology of A.U.TH.

The mechanical behavior of unsaturated soils depends on the characteristic for each soil type angle φ^b as well as the relationship between the soil suction and the degree of saturation as described by the soil water characteristic curve (SWCC) (Fredlund et. al. 2013).

Results/Conclusions

The test results showed:

- An increase of soil shear strength with the reduction of the degree of saturation.
- An increase of the percentage of shear strength variation between saturated and unsaturated conditions with reduced axial stress (Figure 3).
- An observed cohesion of c'=23,5º under natural moisture content while φ remains almost stable under both conditions. Cohesion presentsanincrease with reduced degree of saturation depending on the matric suction values and the angle φ^b (Figure 4).
- The value of φ^b was estimated as φ^b=11,08º using the SWCC to obtain a matric suction value of u_a-u_w=120 kPa for moisture content m=11.20%. This value is in accordance with similar experimental values in the literature.

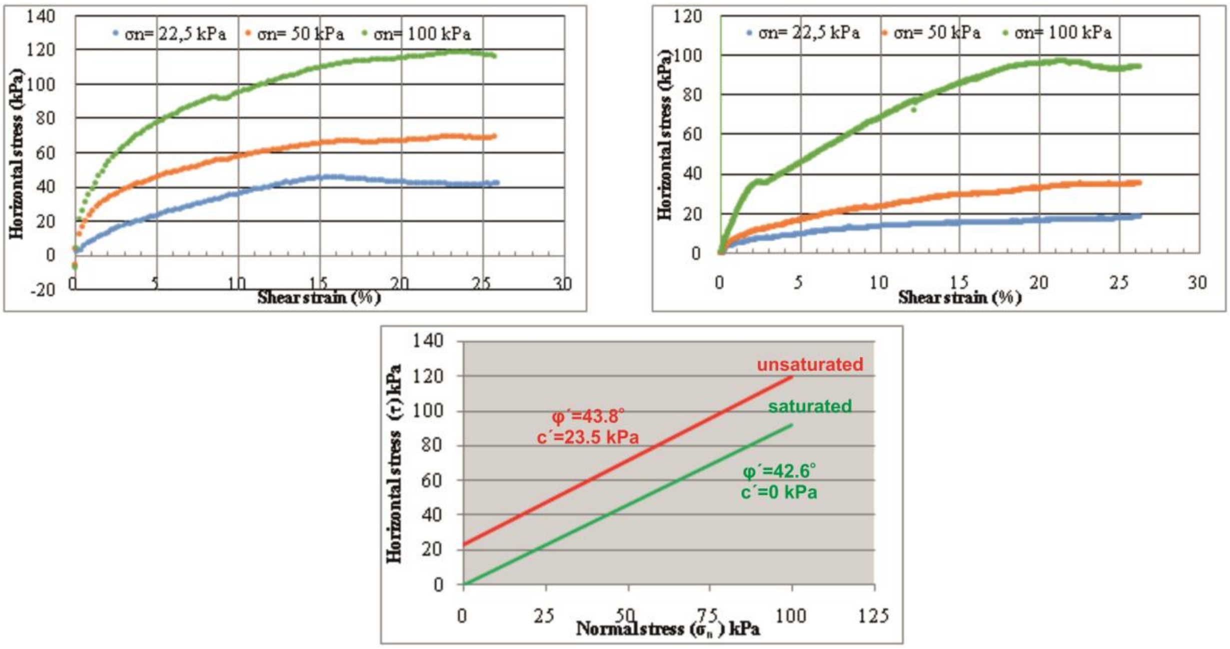

Figure3. Left: Horizontal stress – shear strain diagram for unsaturated conditions. Right: Horizontal stress – shear strain diagram for saturated conditions. Bottom: Mohr – Coulomb failure envelopes for unsaturated and saturated conditions.

References

Fredlund, D.G., & Rahardjo, G. 1993. Soil mechanics for unsaturated soils. John Wiley & Sons.

Fredlund, D.G. &Houston, S.L. 2013. Interpretation of soil-water characteristic curves when volume change occurs as soil suction is changed. Taylor & Francis Group, London.