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# Fine soils-water interactions: study methodologies and main results.

Filomena Canora (1), Francesco Caporale (1), M. Dolores Fidelibus (2), Giuseppe Spilotro (1)

(1) Applied Hydrogeology Laboratory, Università degli Studi della Basilicata, Potenza, Italy, (giuseppe.spilotro@unibas.it/ Tel & Fax: +39 971 205076), (2) Dep. of Civil and Environmental Engineering, Technical University of Bari, Italy

Old statements and recent developments in geotechnical engineering, especially in the field of the clayey soils in semi-arid regions, point the attention to the strict dependence of some geotechnical properties from the chemical composition of pore fluids, when they interact with environmental or free circulating waters of different chemical composition. The related phenomena are of different kinds: suction, osmotic pressure and dielectric properties in the diffuse double layer.

Pore water chemical composition and salt concentration in fine grained soils have been recognized as the third dimension in the physical pressure vs volume behaviour of the soils. The importance of such term is due to the fact that it controls the work of the external forces on a unit of soil mass, and that this work can be positive (for the external forces) with reduction of volume and settlement; this work can be otherwise negative, with swelling or heave in one dimension, if dimension change is allowed, or the development of strong pressures, if this is not possible. Soils, specially near the surface, are not insulated systems; so they can change type and or concentration of pore water, by capillary phenomena and desiccation or wetting. The increase of density associated to the volume reduction normally comes with increase of strength and of stiffness of the materials; the opposite effects are involved in volume increase.

The study of the relationship between physical behaviour of fine grained soils and type of pore water has been performed on blue clays of the wide region geologically

known as Bradanic forethrough in Southern Italy.

The latter aspect is, for the authors, the most important: long term or seasonal variation of ionic concentration in waters circulating mainly along clay fractures determines non steady state situations and causes a disequilibrium between exchange complex and interstitial water. The consequences are the change of both the dielectric property and the field of the electrical forces inside the double layer. Furthermore, a soil, of ancient geological origin, can exhibit, at present, a sudden work against the gravitative force of overburden or of a foundation by swelling or, most rarely, a big settlement under relatively insignificant heads.

These phenomena have been evaluated, up to now, in terms of swelling pressure, as commercial geotechnical equipments do. However, a better understanding is possible in energetic terms: the energy balance is well correlated to the released energy of the soil volume interacting with external waters. Simple oedometric tests can prove it.

Starting from the study of several areas, swelling phenomena were associated to the typical situation of clayey soils with high salinizated pore water in contact along fissures with recent fresh underground waters. The chemistry of pore waters was determined on samples extracted by means of a squeezing technique, with a simple apparatus. According to the double layer theory, the salt content of the squeezed pore water varies and increases with the squeezing pressure. Currently there are no problems in the detection of the salinity of underground environmental waters, by means of ordinary TDS measurements probes or of their sampling. Other soil profiles characterized by flat topographic surface and hi-level of groundwater reveal together low density of the clayey soils and reduced salinity of the interstitial water.

The authors' conclusions follow:

- a complete site characterization cannot be made in stiff clayey soil without the appreciation of both pore water salinity (PWS) and environmental waters (EWS) or, better, without their chemical composition;

- a correct geotechnical behaviour of these soils can be derived only if laboratory test will be performed, allowing these soils to interact with waters of a similar chemical composition of that of pore water: the use of distilled water, in most cases, causes geotechnical parameters to be underestimated;

- if PWS is different from EWS, as when fresh waters interact with stiff fissured marine clays, settlement or heave of structures or foundations can be expected, also without significant changes in effective stresses. Soil density changes induced by jonic diffusion can be also responsible of slope failure;

- PWS can be estimated recovering water samples from clay cores with squeezing techniques; EWS by simple TDS-log in explorative holes.