ABSTRACT

The main objective of this research work focuses on the study of the hydro-mechanical behaviour associated with changes in suction and net stress in a collapsible soil. A laboratory test program was carefully defined using different stress and suction paths, with the aim of enriching the existing body of knowledge regarding unsaturated soil behaviour. The results from the tests were interpreted by means of an elastoplastic hardening model previously developed in the Geotechnical Department (Barcelona Basic Model).

A low plasticity clay, with an artificially prepared structure, statically compacted under isotropic conditions (controlled stress conditions), was chosen for this investigation. After compaction, the total suction of the samples was measured using transistor psychrometers. This preparation method allowed to know the stress and suction history of the samples and their precise initial conditions. The structure of the samples was characterised using mercury intrusion porosimetry, electronic microscopy and a series of previous mechanical tests.

A new controlled-suction oedometer cell was developed and the existent triaxial cell was upgraded in order to carry out triaxial compression tests with controlled suction under constant strain rate.

These controlled-suction isotropic and oedometer tests allowed the study of the volumetric response (collapse, swelling and shrinkage) of normally consolidated and overconsolidated samples. The influence of the initial state was analysed, as well as the effects of applied net stress and the changes of suction in the volumetric behaviour, the permeability and the water retention properties. These tests showed reversible and irreversible features regarding volume change behaviour. Significant plastic strains and irreversible changes in water content, associated with the wetting-drying paths and loading-unloading paths, were observed.

Likewise, the hydro-mechanical response was studied during the application of a deviatoric stress at constant suction, thus analysing the stress-strain response and the hydraulic coupling, and determining the shear strength parameters in normally consolidated and overconsolidated samples. The research consisted in a program of strain-controlled triaxial compression tests under constant

confinement and suction. The overconsolidated state was induced before the shearing phase by means of a hydraulic process (wetting-drying and drying-wetting paths) and a mechanical process (loading-unloading path). The response to shearing of normally consolidated samples was studied for the cases in which the sample achieved a maximum level of mean net stress, as well as after wetting paths with dominant collapsible strains.

During the shearing phase, the samples initially presented compressive volumetric response, while afterwards they showed dilatancy without evidencing any strain softening. Furthermore, in all samples, there was an initial water outlet that attained a stable value after the compressive phase, although any water inlet was detected during the final dilative phase. Test results showed the existence of a critical state line in terms of net mean stress, deviatoric stress and void ratio, whose position depends on the value of suction.

Experimental results were interpreted using the elastoplastic hardening model, which is based on critical state concepts. Soil parameters associated with this model were determined and some stress paths were simulated, which helped to validate the model capacity to reproduce the response of an unsaturated soil.