UNDRAINED LOADING AND COLLAPSE OF UNSATURATED SOILS DURING CENTRIFUGE TESTING. AN EXPERIMENTAL AND NUMERICAL STUDY.

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Abstract: *The paper presents the results of a centrifuge model of a shallow foundation relying of a layer of unsaturated soil and submitted to axial load for different water level. The objective of the work was to represent a foundation of 1.5 m in diameter on a 15 m soil layer. The model of foundation was a circular disk of 30 mm in diameter and the layer was a cylindrical container of 300 mm in diameter and height. In order to maintain similitude between prototype and model the tests were carried out at 50g. The tests were carried out at the LCPC facilities in Nantes (France). The tested material is an eolian silt from Jossigny, East of Paris. In order to decide the initial conditions of the model in terms of water content and void ratio it was performed a preliminary laboratory investigations. As the intention of the study was to examine the behaviour of a collapsible soil therefore it was decided to prepare the model with a low dry density (14.5 kN/m^3). The evolution of pore water pressure during the tests are compared with the numerical simulation of the prototype with code bright.*

1 INTRODUCTION

The study of unsaturated state on the behaviour of a shallow foundation is an important issue. The state of partial saturation play a foundamental rule on the behaviour of the shallow foundation at failure. The objective of the study was to provide experimental data on the effect of suction (unsaturated soil) on the behaviour of a shallow foundation and to validate numerical results for the case of a foundation relying over a layer of unsaturated silt and submitted to axial load for different water levels.

The tested material is a low plasticity silt with clay. Jossigny silt has a liquid limit w_L = 32.3%, a plastic limit w_P = 17%, 25% of particles less than 2 μm and a unit weight of solid particles γ_s = 26.4 kN/m^3. In order to study the effects of wetting at different initial void a series of oedometric tests has been performed for vertical stress σ_v=200 kPa representing a point in the lower part of the prototype.
The deformation induced by wetting are reported as function of initial dry density in Figure 1.
As the objective of the study was to examine the behaviour of a collapsible soil therefore it was decided to prepare the model with a low dry density (14.5 kN/m^3) and band w= 13% (Sr≅42%).
The soil water retention curve has been obtained under suction controlled condition for different void ratios. In Figure 2 are reported the curve obtained in oedometer cell under suction controlled conditions; the branch of SWRC obtained by Mercury Intrusion Porosimetry on a samples compacted at the dry unit weight of 14.5 kN/m^3 and the point obtained from equalization stage in oedometer and triaxial cell (Casini et al 2012[i]). It was

decided to prepare the sample at a Sr≅42% (e_0=0.82) which correspond a suciotn s≅200 kPa so all the point follows the wetting branch of soil water retention curve when the sample is connected with the water at base in order to avoid the effects of hysteresis

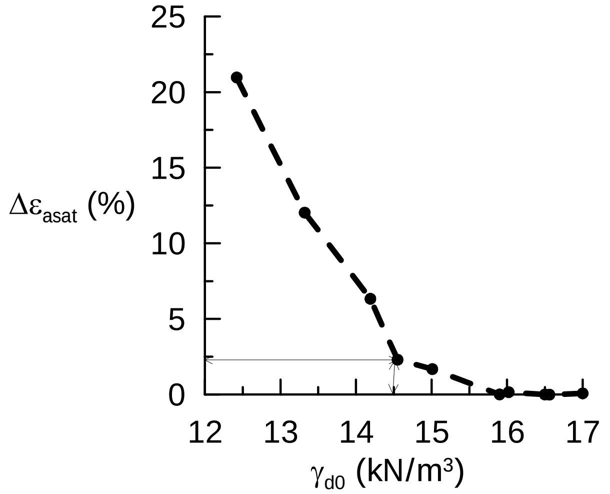

Figure 1 Deformation at saturation- initial dry unit weight.

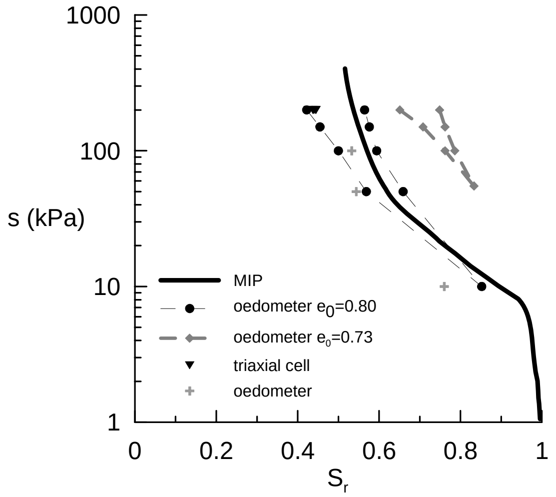

Figure 2 SWRC obtained at different void ratios

2 EXPERIMENTAL APPARATUSES

The samples was compacted statically in a cylindrical container using a 5.0 ton load frame. The procedure set-up used it was the same of previous campaigns performed at ENPC (Cui et al.2005[ii]). It have been prepared in total eight samples (each one weight 35 kg), the properties are reported in table 2 (Casini et al. 2012 in prep[iii].).

Sample	*w* *(%)*	γ_d *(kN/m3)*	σ_{vc} *(kPa)*	Laboratory
F-1	13.17	14.36	296	ENPC
F-2	16.85	14.12	65	ENPC
I-A	13.9	14.30	189	LCPC
I-B	13.28	14.24	220	LCPC
I-C	13.75	14.54	196	LCPC
II-D	13.75	14.44	208	LCPC
II-E	15.1	14.29	180	LCPC
II-F	12.54	14.57	215	LCPC

Table 2. After compaction properties of the samples used in the centrifuge

In Figure 3 is reported the instrumentation and its position on the sample. It was installed six tensiometers (five in the first campaign) on the diametral opposite sides. Three tensiometers provided by CERMES (labelled ENPC) and three provided by Durham University (labelled DU) in the figures. The elevation are reported in the figure 3. One water pressure transducer was installed at the base of metallic container in the sandy layer in order to control the water pressure in the model.

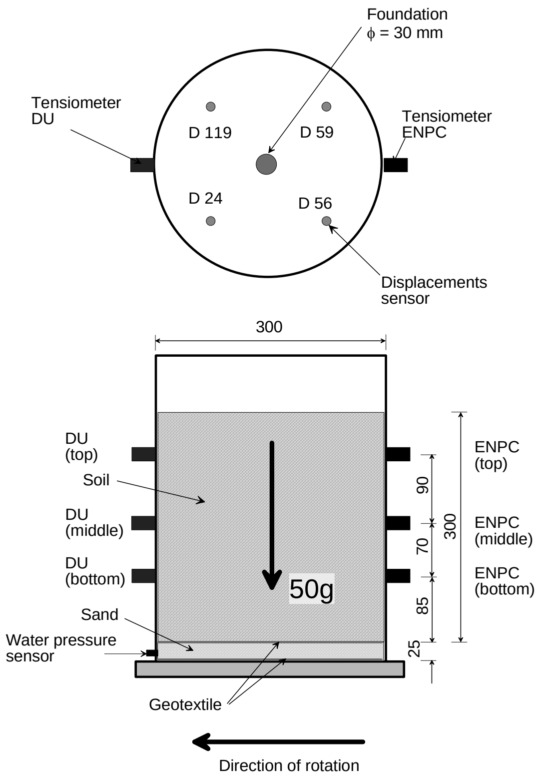

Figure 3. Instrumentation on the sample in centrifuge.

A circular metallic disk (foundation) has been put in the centre of the sample. Load was applied through a spherical hinge to avoid any overturning moment and eccentricity. The load of foundation was performed at a constant displacement rate and the resulting load measured by a load cell. Four LVDT allowed for measuring the vertical displacements at the top of the sample along four radii regularly distributed around the axis of foundation at a distance close to 10 cm (one alone at a distance close to 3 cm in the second campaign).

3 RESULTS

The load of foundation was performed for three height of water level. Defined H_w the height of water level measured from bottom of layer, H the height of layer (Figure 4), the load of foundation was performed for H_w=H, H_w =H/2 and H_w=0.

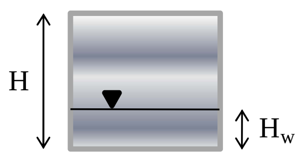

Figure 4. Water level in the model

The evolution of pore water pressure and displacement measured during the test D, are reported in Figure 5 with the comparison with the prediction of a FEM analysis performed with code_bright using the Barcelona Basic Model. An attempt to simulate the effect of increasing the gravity acceleration from 1g to Ng, with N=50 is also perfomed.

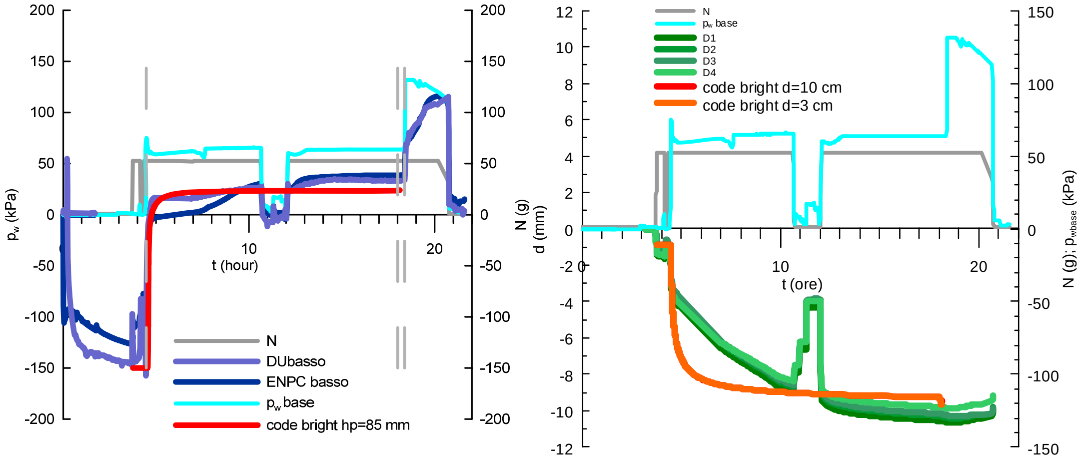

Figure 5. Pore water pressure and displacement evolution during test D.

4 CONCLUSIONS

The results of the centrifuge tests performed on an unsaturated layer of silty soil are presented. The evolution of pore water pressure and displacement are compared with the numerical simulation performed with code_bright. The simulation agree quite well with the measurement. An attempt to simulate the effect of changing the gravity acceleration from 1g to Ng is also performed in order to reproduce the change in suction measured putting in flight the sample and stopped it.

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