Discussion of "Volume Change Behavior of Collapsible Compacted Gneiss Soil," by Jose H. F. Pereira and Delwyn G. Fredlund

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The topic of collapse settlement due to flooding in compacted soils is today considered of maximum interest, specially for the design of foundations of buildings on structural fills. Similar requirements to those specified in road construction, referred to the standard Proctor maximum density and optimum moisture content, are sometimes extrapolated to the case of structural fills, what may lead to unsuccessful results. But, even in road construction, this type of specifications is sometimes questioned, when possible collapse phenomena are involved.

The more general approach of gradual collapse due to a decrease in suction, even without arriving to flooding, subject of the paper we are going to discuss, is therefore very appropriate in order to get a broader view of the problem.

Tests similar to those described by the authors were performed by the discusser (Escario and Saez 1973a) and presented as an oral discussion. The authors quote in their list of references another paper presented by Escario and Saez (1973b), not so closely related to the topic of their paper. In this discussion we are going to comment the Moscow results and it will be seen that they show very similar results to those presented in the paper by the authors, but with some shades that we think are worthwhile to be commented.

The tests presented by the discusser were carried out with the pressure membrane oedometer under controlled suction, as described in the Haifa Conference. The soil was a Miocene clayey sand of Madrid ("arena de miga") with the following characteristics: liquid limit = 32; plasticity index = 15; % passing No. 200 sieve = 15.5; std. proctor maximum density = 1.98 t/m^3; proctor optimum moisture content = 11%.

All samples were statically compacted to the same density of 80% maximum Proctor. The moisture content was different in the three series of tests: 3, 6, and 8%, all of them below the 11% optimum proctor.

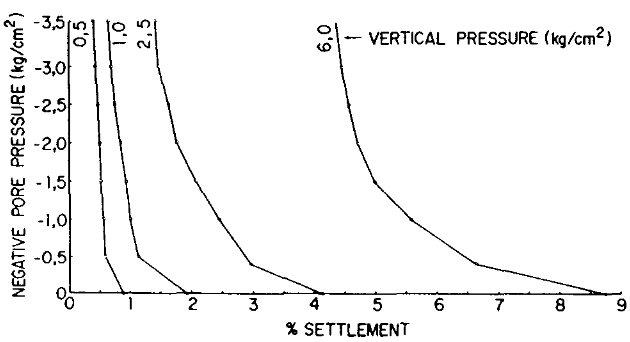

Fig. 1. Compaction moisture content, 3%

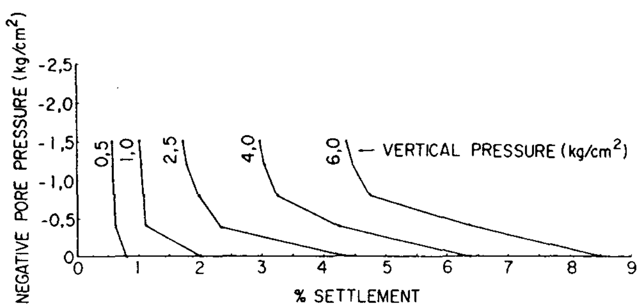

Fig. 2. Compaction moisture content, 6%

In Fig. 1 the 3% series is shown. Each curve corresponds to a sample which was initially consolidated under the corresponding surcharge at the after compaction suction value; then the suction was progressively decreased until zero value. As it may be seen, the settlements induced by the suction decrease process (initiated at the origin of each curve, which includes soil plus membrane deformation) are not large until a relatively low suction value is attained, where upon the process is considerably accelerated, leading to what might be called collapse. This tendency is similar in the other two sets of curves (Figs. 2 and 3).

Therefore, as mentioned before, the general tendencies of the discusser results are practically the same as the ones presented by the authors. Nevertheless, the following comments can be made:

1. As it may be observed in the curves presented by the discusser, for very low vertical pressures, the collapse phenomenon does not practically show up until very low suctions are reached. But for vertical pressures of 6.0 kgf/cm^2, collapse settlements start almost from the very beginning and continue at an increasing rate as the suction is decreased. The only general trend that can be observed from the data both of the authors and the discusser is that the collapse phenomenon does not get strongly accelerated until relatively low suctions are attained: the lower, the smaller the confining stress. The efforts of the authors to differentiate between the precollapse and the collapse phases have to be considered with an extreme caution until a more extensive testing on the subject is carried out.
2. In the tests carried out by the discusser, no postcollapse phase was detected. Certainly, the last step of suction was of 0.5 kgf/cm^2, without any intermediate step before arriving to

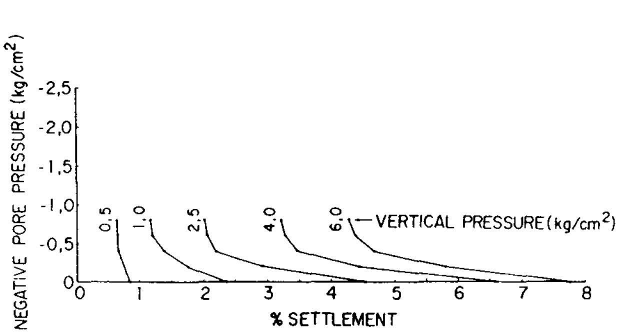

Fig. 3. Compaction moisture content, 8%

zero suction. The discusser feels very skeptical about the actual existence of such phase and thinks it may only be a consequence of the type of test used by the authors: towards the end of the saturation process and due to the inevitablein-accuracies of the process followed, the suction value may show up as practically zero, even though the soil has not been fully saturated due to the presence of air bubbles.

The discusser wants to encourage the authors to follow the very interesting research undertaken and congratulate them for the preliminary results obtained on such an important topic.

References

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Closure to "Volume Change Behavior of Collapsible Compacted Gneiss Soil," by Jose H. F. Pereira and Delwyn G. Fredlund

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Firstly the authors thank Dr. Ventura Escario for his interest and contributions to the above paper. The discussion enhances the paper and provides an opportunity to advance additional details on the subject at hand.

The first observation made by the discusser was the absence of the reference (Escario and Saez 1973) regarding the gradual collapse of soils caused by a suction decrease. The authors recognize the need for including this reference, which was used by Pereira (1996) who reproduced Fig. 1 as presented by Escario (1973) in Fig. 1 of his discussion. In the proceedings of the ICSMFE, held in Moscow in 1973, there is no title for the Escario (1973) contribution. The reference list in this closure uses the title provided

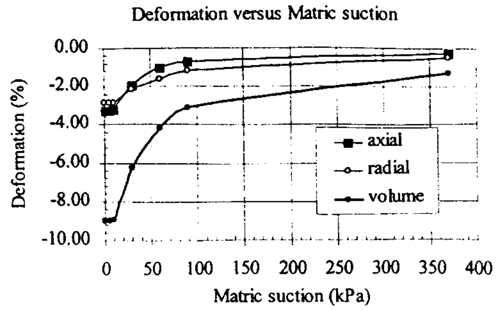

Fig. 2. Deformation measurements during wetting on test TPT4 (Pereira 1996)

by the discusser. There is also need to correct the reference Escario, V. (1973) to Escario and Saez (1973) in the original paper. This correction is added here to the reference list.

The second observation from the discusser addresses a concern regarding the definition of the metastable soil precollapse phase. In response, the authors make mention of the literature providing experimental data and modeling for soils which first expand and later collapse along a wetting path (Alonso et al. 1993; Sivakumar and Wheeler 1993). Any compression behavior along a wetting path is usually referred to as plastic deformation. This might imply an additional complexity to the proper formulation for the soil model. Precollapse phase was defined in accordance with the experimental data reported in the original paper. It is the authors' opinion that consideration of the precollapse phase, along the wetting path provides additional information on the formulation of a simplified soil model for metastable-structured soils (Pereira and Fredlund 1997). The precollapse phase could be better defined, for instance, by using laboratory tests wherein wetting-drying suction controlled tests are conducted under a constant applied isotropic net stress state.

In his third observation, based on his experimental data, the discusser expresses skepticism regarding the postcollapse phase experienced by the metastable-structured soil studied. Firstly, it is important to emphasize that one of the fundamental differences between the data presented by the discusser and the data from the authors relates to the stress level, mainly in terms of matric suction stages tending towards saturation. Therefore, the discusser's data do not provide sufficient information to define the existence

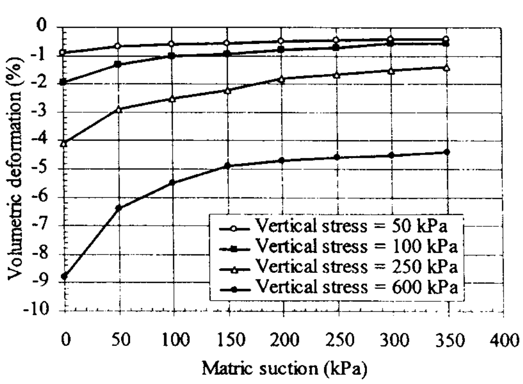

Fig. 1. Volumetric deformation versus matric suction (modified from Escario 1973)

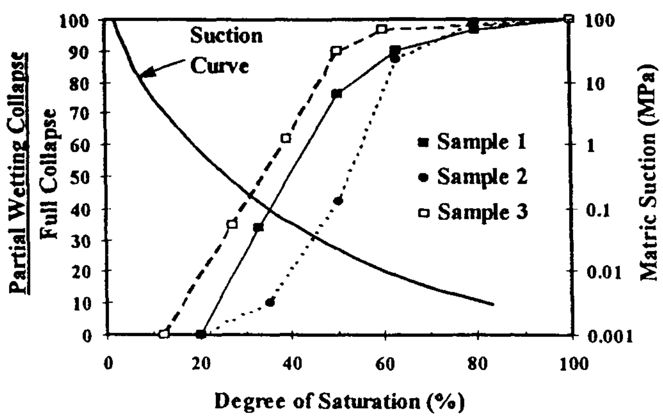

Fig. 3. Soil collapse evolution upon wetting (after Houston et al. 1993)

or the nonexistence of the postcollapse phase for the metastable-structured soil (i.e., the compacted clayey sand tested by the discusser).

The authors presented the calculated degrees of saturation in the paper, which shows values equal to 100% as the backpressure was applied to the soil specimen. Even when by applying this backpressure, while keeping the confining stress constant, no additional collapse was observed in the soil specimens. In addition to the data previously shown in the paper, Fig. 2 presents the evolution of the soil deformations for test TPT4 (i.e., under a net confining stress equal to 200 kPa). The deformations are presented in terms of both radial and axial components of strain as well as total volumetric strain. The postcollapse phase is well defined in Fig. 2. It is also important to mention that the noncontact transducers utilized in the experiments possessed accuracy in the order of 0.01 mm, and the data acquisition system presented a stable response, without any undesirable noise.

In the paper, the authors mentioned that Houston et al. (1993) showed similar results, in terms of postcollapse soil behavior. The results obtained by Houston et al. (1993), for a sandy silt, are illustrated in Fig. 3 which shows the collapsing soil specimens reaching total collapse due to wetting under Ko-conditions, at matric suctions values of about 4 kPa. This suction value corresponds to a degree of saturation of about 80%. A net vertical stress was applied to the soil specimens at their unsaturated conditions. According to Fig. 3 the soil specimens had initial values of matric suction in the order of 10,000 kPa.

In conclusion, the authors reinforce that the discusser has raised important concerns related to key points in the paper regarding the behavior of collapsing soils along wetting stress paths. It is also recognized that there is need for additional and specific information on volumetric changes suffered by a loaded metastable-structured soil when moving along a wetting path.

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