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Collapse strains and at rest lateral stresses under controlled suction on a lateritic soil

Effondrement et pressions au repos sous succion contrôlée sur un sol latéritique

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ABSTRACT: Collapse behaviour and at rest lateral stresses of a poorly compacted lateritic soil tested in laboratory under controlled suction are addressed. It is shown that significant collapse strains can be induced even at relatively large suctions, during wetting of soil, but maximum values are attained at zero suction. At rest lateral stresses seem to be governed by suction and overconsolidation ratio, being lower for higher suction values, during first loading of the soil.

RESUMÉ: Quelques résultats d'essais oedométriques réalisés sous succion contrôlée sur un sol latéritique compacté sont présentés. Les déformations partielles provoquées par la réduction de succion (humectation graduelle) sur l'échantillon sont analysées et il est montré que déformations significatives peuvent occurrir pendant l'humectation et avant de la saturation du sol. Il est montré aussi que les pressions de terre au repos sont influencés par la succion et par la relation de surconsolidation.

1. INTRODUCTION

In recent years there has been an increasing interest on the study of non saturated soils. Although many soil problems associated to moisture content variations, such as collapse and expansion, have been dealt with by many authors, the influence of suction in the behaviour of those soils has not been sufficiently studied.

In this paper, test results obtained from a suction controlled oedometric cell which allows the measurement of lateral stress are used to study collapse behaviour of a lateritic soil. Collapse strains following suction reduction are analyzed as well as the influence of suction on lateral stress.

The cell is provided with a high air entry value porous stone (15 bar) encrusted in its base which allows to impose suction to the sample according to the axis translation technique. To get the desired suction, soil samples were firstly wetted and then drained. Equilibrium suction was monitored by the water draining the sample. Depending on the suction, time for equilibrium varied between seven and fifteen days. Lateral stresses were measured through strain gages affixed to the confining ring.

2. SOIL STUDIED

Results of tests performed on a poorly compacted lateritic soil are analyzed considering the influence of suction on confined compression curves and on the gradual collapse of soil upon increasing wetting (suction reduction).

The soil studied is a clayey sand having liquid and plasticity limits of 38% and 24%, respectively, and particle unit weight of 27,5 kN/m³. In MCT (Miniature, Compacted, Tropical) classification system (Nogami & Villibor, 1981) it belongs to LG' Group, which means that the soil is a lateritic clayey soil. Standard Proctor compaction parameters are maximum dry unit weight of 17,9 kN/m³ and optimum moisture content of 17%. As collapse behaviour was the main point of interest of the study, soil was poorly compacted to dry unit weight of 14 kN/m³ (degree of compaction of about 80%) and moisture content of 12% (5.0% drier than optimum water content, considering Standard Proctor test).

3. ANALYSIS AND DISCUSSION OF TEST RESULTS

Figure 1 shows confined compression curves under constant suction. Samples at larger suctions (drier samples) became stiffer

and were capable of sustaining larger loads with little deformation. This caused an increase of preconsolidation pressure as it was expected. The saturated sample and those samples tested under suctions up to 120 kPa tended to reach the same void ratio at loads of 1200 kPa, while those tested with larger suctions did not show similar behaviour. This indicates some influence of suction on compression index (Cc).

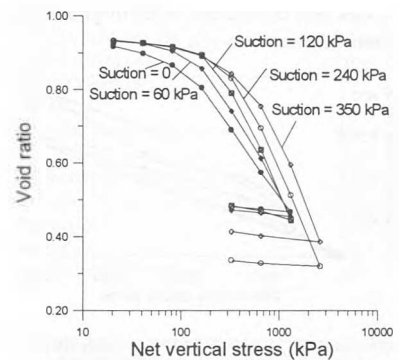


Figure 1: Confined compression curves under controlled suction.

Figure 2 shows the results of samples loaded under constant suction (400 kPa) to overburden stresses of 330, 660 and 1320 kPa and then wetted by decreasing suction. During wetting, suction was reduced in stages, firstly to 200 kPa and then to 100, 50 and zero kPa. The observed collapse strains for different suctions are also plotted in Figure 3, for constant overburden stress.

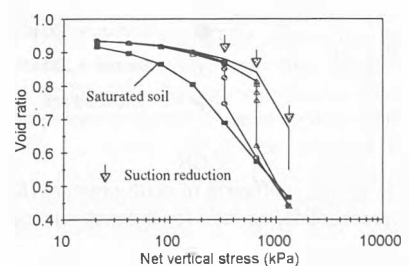


Figure 2: Confined compression curves and collapse strains during gradual wetting (suction reduction).

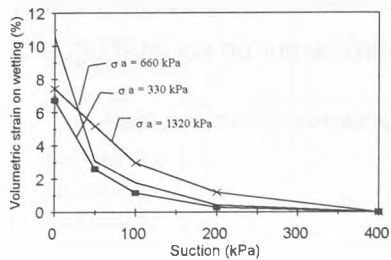


Figure 3: Collapse strains for different suctions and constant overburden stress.

From figures 2 and 3 it can be noted that samples loaded under constant suction to an overburden stress and then wetted have shown collapse strains that are dependent upon overburden stress and suction. An interesting feature is that wetting induced strains were also of significant magnitude during gradual sample wetting, even when suctions were relatively large. These results show that collapse can take place in non-saturated soils by moisture content fluctuations, as it could happen during seasonal climatic variations, without the need for saturation or near saturation of the soil. As suction decreased collapse strains increased reaching their maximum at zero suction (saturation or near saturation of the sample) as it was expected. Final strains (at zero suction) have increased with overburden stress up to a maximum and then have decreased in a similar behaviour to that reported by many authors when testing natural collapsible soils (Carvalho, 1994).

The influence of suction on lateral stress was analyzed considering different stress and suction paths. Figure 4 shows the results of a first series of tests which were performed under constant suction. Figure 5 shows at rest coefficient of earth pressure (K_0), plotted against overconsolidation ratio (OCR).

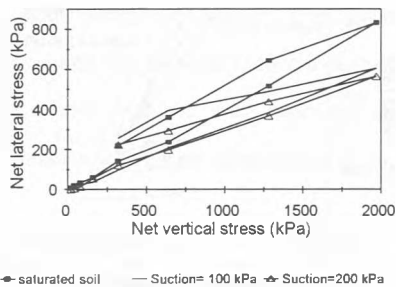


Figure 4: Lateral and vertical stresses for different suctions.

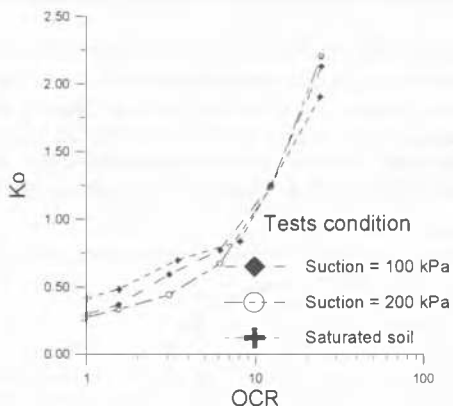


Figure 5: At rest coefficient of earth-pressure (K_0) and overconsolidation ratio for different suction.

These results show that during the loading process a quasi constant value of K_0 was measured, but during unloading K_0 varied according to the over-consolidation ratio of the sample, in a behaviour similar to that reported by Dyvik et al. (1985) when

testing clays. During loading, K_0 reached 0.42 for zero suction while for suction of 200 kPa it decreased to 0.25, showing the increase in soil stiffness with soil suction. During unloading, the soil ability to sustain part of previous lateral load influences K_0 values. Lateral stresses are released at a lower rate than vertical ones, leading to larger values of K_0 as OCR increases. K_0 reaches values as high as 2.2, for suction of 200 kPa and OCR of 25. It is interesting to note that for OCR larger than 10, K_0 values tended to be close, but K_0 for saturated soil tended to be lower than those values measured in the soils tested under higher suctions.

Finally, Figure 6 shows test result in which lateral stresses were measured during gradual collapse caused by suction reduction, for vertical stress of 660 kPa. As suction is reduced, from 100 kPa to zero, lateral stresses tended to increase, with K_0 ranging from 0.25 to 0.39. The K_0 value found at final wetting process was close to those obtained in saturated soil tests. So, wetting of collapsing soils apart from causing wetting induced strains, tend to increase at rest lateral stresses which are dependent on suction, at least in laboratory tests. Obviously, the limitation of laboratory tests to measure in situ stress is recognised, since sampling and trimming will disturb the state of stress in the soil. However it must be recognised that laboratory tests are a useful tool to study at least qualitatively at rest soil lateral stresses.

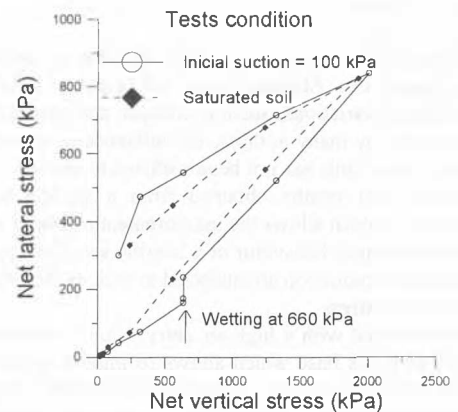


Figure 6: Lateral stresses during gradual collapse caused by a reduction in suction.

4. CONCLUSION

The poorly compacted lateritic soil (degree of compaction of 80 % and $\Delta w = -5.0\%$) showed that suction increases preconsolidation pressure and interferes on compression index, in the stress range used in the tests. Significant collapse strains can take place for high suction values, depending on overburden stress, but maximum values are associated to zero suction. Lateral stresses and K_0 values are dependent of suction and OCR. During loading, K_0 is almost constant, is higher for saturated soil and tended to decrease as suction is increased. As soil gradually collapses lateral stresses tend to increase and to reach values corresponding to those of saturated soil.

5. REFERENCES

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