XIII ICSMFE, 1994, New Delhi, India / XIII CIMSTF, 1994, New Delhi, Inde

PEDOGENESIS AND ITS RELATIONSHIP TO LATERITIC COMPRESSIBILITY AND COLLAPSIBILITY

PEDOGENESE ET SES RAPPORTS AVEC COMPRESSIBILITE ET AFFAISEMENT DANS LES LATERITES

Regina Davison Dias

Associate Professor, Rio Grande do Sul Federal University
Porto Alegre - RS, Brazil

SYNOPSIS: Geotechnical test results in lateritic soils are presented in this work. These soils are originated from basalt and sandstone and cover about 37.000 km² in the South of Brazil. Field investigation was carried out in seventy sites, and undisturbed block samplings and laboratory tests were undertaken in five different lateritic soils. Soils on its natural structure were tested to assess compressibility and collapsibility behavior. Soil structure markedly influence mechanical behavior of lateritic soils in which the pedogenetic process is more intense. Lateritic soils have a macrostructure formed by aggregates particles. The aggregates are formed by a group of particles strongly bonded, but the connection amoung aggregates can be weak or strong, showing then different compressibility and collapsibility behavior.

INTRODUCTION

Laterization or Latolization is a pedogenetic process typical from hot and humid regions. Silica and cations are carried through hydrolyses and minerals presented in the original material are transformed in iron and aluminium oxides or kaolinites soils with oxides. Clay or sandy lateritic soils are partially saturated. Lateritic soils are formed in many places in the world. In Brazil they are found in almost all regions - in Northeast a yellow color is predominant, whereas in Southern they are red. Lateritic soils have a macrostructure formed by aggregate particles with subangular shape. Those particles can change in size and degree of development. Soils behavior is governed by aggregated particles, which in fact behave like an individual particle. These soils have macro and micropores, the macropores being permeable and the micropores being less permeable than macropores.

GEOTECHNICAL UNITS AND CHARACTERISTICS

Pedology was used to describe the superficial horizons (A and B) and geology to describe horizon C and bedrock. Five geotechnical units were investigated. Unit 1 (LEs) contains soil classified as Red-Dark Latosoil and substract sandstone. Unit 2 (LEb) contains soil also classified Red-Dark Latosoil and substract basalt, but the B horizon contains contaminations from sandstone action. Unit 3 (LRb) is classified as Purple Latosoil with basaltic bedrock. Units 4 (LBRb) and 5 (LBCb) are less developed on its Latosoils pedological genesis. They are classified as Brune-Purple Latosoil (LBRb) and Brune-Cambic Latosoil (LBCb) and both have basaltic substract. The development of the Latosoils increase with the pedogenesis process action.

Table 1 shows the average values of grain size distribution, plastic limits and colloidal activity. These soils do not contain sand or gravel. The variation coefficient from statistic analysis is lower than 25%, as obtained from fifty test results. Unit 1 contains fine sand lateritic soils. The others units are predominantly clay soils. Standard Penetration Test results show that the number of blows are generally inferior to 8 in a typical lateritic profile. A variation of N SPT from about 2 blows to 15 blows can be observed. Average values of unit weight, voids ratio, porosity and degree of saturation are shown in Table 2, which summarizes results from more than a hundred tests from all units. For each geotechnical unit six samples were used for determining the coefficient of permeability.

Table 1 - Average values of characteristics of units

Geotechnical Units	thickness B horizon	sand med. %	fin. %	silt %	clay %	W_L %	W_p %	A_c %
LEa	4 - 15m	3	51	13	33	38	25	0.39
LEb	4 - 15m	2	24	21	53	53	37	0.30
LRb	3 - 20m	1	14	27	58	57	41	0.28
LBRb/LBCb	2 - 8m	1	22	14	63	63	42	0.33

Table 2 - Average values of unit weight, void ratio, porosity, degree of saturation and coefficient of permeability

	W %	γ_s KN/m³	γ KN/m³	γ_d KN/m³	e %	n %	S_r %	K(x10^{-6}) m/s
LEa	19.1	27.5	15.7	13.2	1.09	51.3	49	6.2
LEb	32.2	28.4	15.5	11.8	1.41	58.3	66	4.5
LRb	34.0	29.1	15.5	11.5	1.55	60.2	67	8.4
LBRb/LBCb	38.9	28.1	15.9	11.1	1.58	61.2	78	4.2

BEHAVIOR IN CONFINED COMPRESSION TEST

Results of confined compression tests carried out in soaked specimens are presented in Figures 1 to 4. In this case, soaking process almost eliminate suction effects in the macrostructure. Only suction in micropores and cementation are presented. Davison Dias (1988) has shown these effects in triaxial compression tests.

Figure 1 shows the results of soils classified as LEs. Its structure is formed by quartz connected to iron and aluminum oxides and a few number of aggregates. Particle connections are not stable and as a result displacements up to overconsolidation pressures are virtually the same to all soils in soaked conditions. Virtual overconsolidation pressures occurs in the range of 50 to 100 KN/m². Figure 2 shows the results of soil classified as LEb. These soils are clayer than LEs due to basalt substract, and the structure presents more aggregate than LEs. Virtual overconsolidation pressures also occur in the range of 50 to 100 KN/m². Displacements measured in one LEb soil are considerably smaller than the levels exhibited by other soils. This behavior is thought to be a result of stronger connection aggregates.

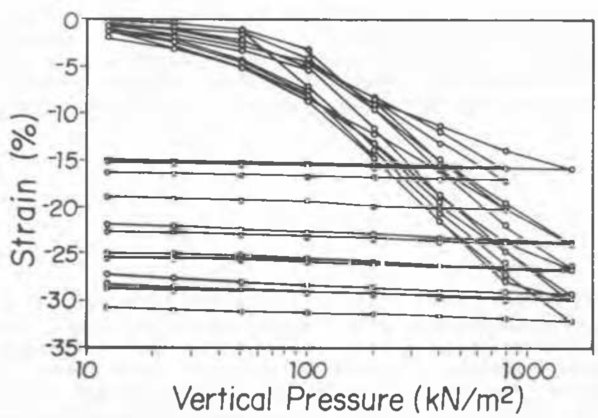

Figure 1 - Results of confined compress tests carried out in B horizon of ten sites classified as LEs.

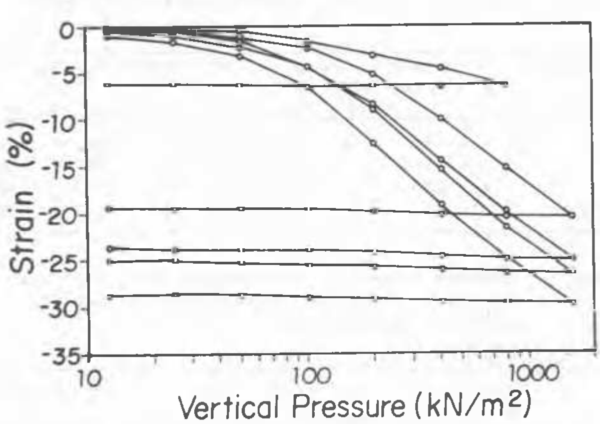

Figure 2 - Results of confined compress test carried out in B horizon of five sites classified as LEb.

Figure 3 shows the results of Purple Latosoils of Rio Grande do Sul (RS) in the subtropical region which do not suffer intensive process of weathering. As a result the structure is less compressible than the same Latosoils from regions closer to the tropics where the pedogenetic process is more intense (more developed soils). Virtual overconsolidation pressure is observed at pressure levels greater than 100 KN/m². More developed Purple Latosoils can exhibit a more compressive behavior than RS soils where overconsolidation pressure occurs at 25 KN/m². More developed Latosoils can exhibit stable connections inside small aggregate particles, but unstable connections among aggregates. Such a connections are stronger in RS soils (less developed).

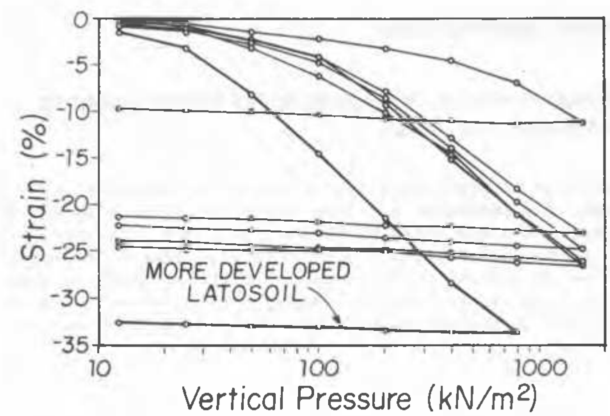

Figure 3 - Results of confined compress test carried out in B horizon of six sites classified as LRb.

Figure 4 shows the results of Brune-Purple Latosoils (LBRb) and Cambic-Brune Latosoils of Rio Grande do Sul. The Brune-Purple Latosoil can be classified as an intermediate stage between Brune Latosoil and Purple Latosoil. The B horizon of Cambic-Brune Latosoil is the least developed soil in the Latosoil class. Virtual overconsolidation pressures occur at stress levels greater than 100 KN/m². The curves obtained in soaked tests show a very similar patter to pressure levels that are lower than the overconsolidation pressure. Connections inside aggregates and among aggregates both very strong.

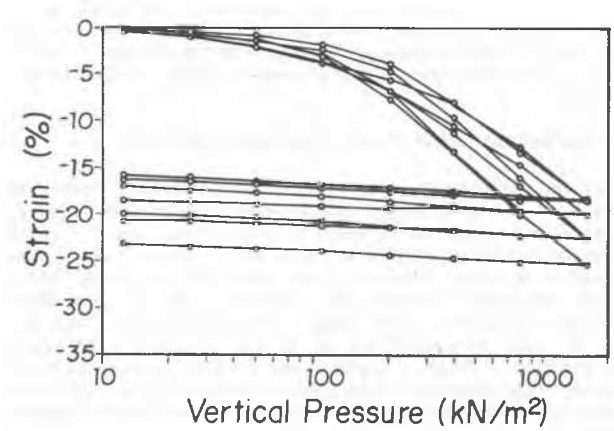

Figure 4 - Results of confined compress tests carried out in B horizons of seven sites classified as LBRb and LBCb.

All Latosoils described in this work have a similar aspect in the field. However the analysis of the macrostructure as described by Nikiforoff (1941) and used in the

Soils Survey Manual (1951) can be useful to assess lateritic soils behavior.

Profiles exhibiting homogeneous aspect can sometimes easily break in small aggregates of granular size. In general, these soils present high compressibility, low shear strength and collapsibility behavior. Virtual overconsolidation pressure lower than 100 KN/m^2 are often observed. Soils that break in larger aggregates and have strong connections among aggregates are stiffer, exhibit lower collapsibility and higher shear strength. Virtual overconsolidation pressures are usually greater than 150 KN/m^2.

The name virtual was suggest by Vargas (1970) because tropical soils are subjected to different formation process. Virtual overconsolidation pressures were shown to range from 40 to 295 KN/m^2, regardless pedology classification. Red-Dark Latosoils and Purple Latosoils exhibbit lower overconsolidation pressures. Small overconsolidation pressure levels are linked to structural behavior, and structure is closely connected to the degree of development of the soil. Less developed Latosoils such as Brune-Purple Cambic and many Purple Latosoils generally present higher overconsolidation pressures.

COLLAPSIBILITY

Barden et al. (1973) have indicated that collapse can take place in partially saturated soils - there is a pressure level at which collapse develops when cement agents are broken. Some authors suggest that collapsibility is controlled by voids ratio and water content.

Figure 5 shows values of structure collapse coefficients in samples collected in different places. By combining the geotechnical characteristics of lateritic soils to test results it is possible to indicate that 1) all lateritic soils are partially saturated and exhibit different collapse coefficient. 2) voids ratio is not an indicator of collapsibility in lateritic soils. Clearly LBCb and LBRb have shown high values of voids ratio (Table 2) and low values of collapse coefficient.

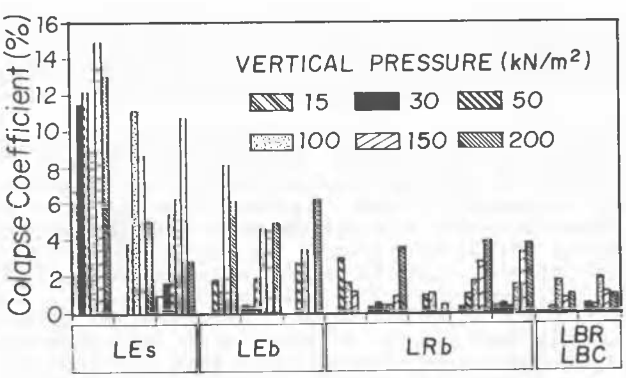

Figure 5 - Results of collapsibility tests carried out in samples of different places.

Vargas (1974) suggests that collapse coefficients lower than 2 are acceptable. The collapse coefficient is not acceptable to soils of low water content. LEa and LEb are under this category. The soils with higher water content are associate to a greater clay content and therefore have an aggregated structure. These soils have water content inside aggregates and among aggregates. The soils LEs have greater fine sand, a few number of aggregates and more quantity of quartz. The aggregates are formed by a group of particles strongly bonded, but the connection among aggregates or quart particle bounded with iron and aluminum oxides can be weak presenting collapse. Collapse coefficients lower than 2 are acceptable for soils in which stronger connections among aggregates are observed.

LEs were found to have higher coefficients of collapsibility, independently from their subtropical or closer to tropical origin. LEb unit has also presented high values of coefficient of collapsibility. LBRb and LBCb soils are less developed, having a more stable structure and exhibit lower values of collapse coefficient.

CONCLUSIONS

The study identified the importance of the genesis and the macrostructure of the soil through the concepts of pedology and geology. Compressibility and collapsibility of lateritic soils depend on pedological macrostructure. Latosoils subject to a more intensive pedogenetic process are more compressible and exhibit collapsible behavior.

ACKNOWLEDGEMENTS

The author is grateful to FINEP, CNPq and FAPERGS for their support to this study. Thanks are also to my friend and colleaque Fernando Schnaid for his help in the preparation of this paper.

REFERENCES

Davison Dias, R. (1988). Influence of The Moisture Content in the Shear Strength of Undisturbed Lateritic Soil. In: SECOND INTERNATIONAL CONFERENCE OF GEOMECHANICS IN LATERITIC AND SAPROLITIC SOILS, Vol. 1 Singapore.

Nikiforoff, C. (1941). Morphological Classification of Soil Structure. Soil Science. Baltimore.

UNITED STATES DEPARTMENT OF AGRICULTURE (1951). Soil Survey Manual. Handbook num. 18 Washington USDA.

Vargas, M. (1970). Origem, propriedades e natureza dos solos residuais indeformados. Publicação 2/70. COPPE/UFRJ.

Vargas, M. (1974). Engineering properties of residual soils from South Central region of Brazil. In: INTERNATIONAL CONGRESS OF THE INTERNATIONAL ASSOCIATION OF ENGINEERING GEOLOGY, 2., São Paulo, Aug. 1974. PROCEEDINGS. São Paulo, Associação Brasileira de Geologia de Engenharia, 1974. V.1, p.IV-Pc - 5.1/5.25.