Some mechanical correlations in the Valley of Mexico Clay

Corrélations des propriétés mécaniques de l'argile de la Vallée de Mexico

A. RICO R., General Director, DGST. SCT. Mexico
J. L. LEON T., Subdirector of Geotechnique, DGST. SCT. Mexico
E. JUAREZ-BADILLO, Technical Adviser, DGST. SCT. Professor, UNAM. Mexico
J. M. OROZCO, Director of Studies. DGST. SCT. Mexico

S Y N O P S I S Some mechanical correlations of a clay from the Texcoco Lake in the Valley of Mexico are presented. First, the values of γ (slope of the log (1+e)-log σ'_v in virgin region) are related to the liquid limit, w_L. Second, the undrained shear strength, s_u, and the cone penetrometer strength, σ_c, are related to the in-situ effective vertical stress, σ'_v. Some practical conclusions are proposed and finally a warning is commented about the indiscriminate use of the electric cone penetrometer.

1. INTRODUCTION

As it is well known, a great amout of research has been done about the strength and compressibility of the Valley of Mexico Clay. In this paper another contribution is presented for gaining more experience about its behaviour.

Due to maintenance necessities it was needed the execution of five borings in the Mexico City Airport. Adyacent, five electric cone penetrometer explorations were done. The results of triaxial unconsolidated undrained and cone penetration tests were analyzed and some conclusions are proposed. The results of consolidation tests were used to apply the theory developed by Juárez-Badillo (1969); some new correlations and interesting conclusions are proposed.

In the following paragraphs, a description of all works and analysis is presented.

2. WORK DESCRIPTION

All five borings were executed using the conventional Shelby sampler. Four inches diameter undisturbed samples were obtained. The maximum depth varied from 20 to 57 m. Four borings were made in a first stage and the fifth was executed in a chosen place for comparison purposes. All triaxial tests were performed in samples obtained in the fifth boring.

The five electric cone penetrometer explorations were executed employing a device consisting of two electric cells to measure the necessary force to penetrate a 60 degree and 3.6 cm diameter cone. It is possible to measure lateral friction, as it is usual in this type of apparatus, but the results are not presented here. The penetration rate employed during all tests was 2 cm/seg. A detailed description of the device is given by Santoyo and Olivares (1980). The maximum depth explored varied between 28 and 38 m. Fig. 1 shows the location of all borings and explorations executed. The consolidation tests were performed in standard consolidometers. Load increments were applied every 24 hours. In some tests the load increment ratio was smaller than one mainly at vertical stresses, σ'_v, smaller than the pseudo-preconsolidation stress, σ'_p. The data obtained was plotted in e-log σ'_v and log (1+e) -log σ'_v curves.

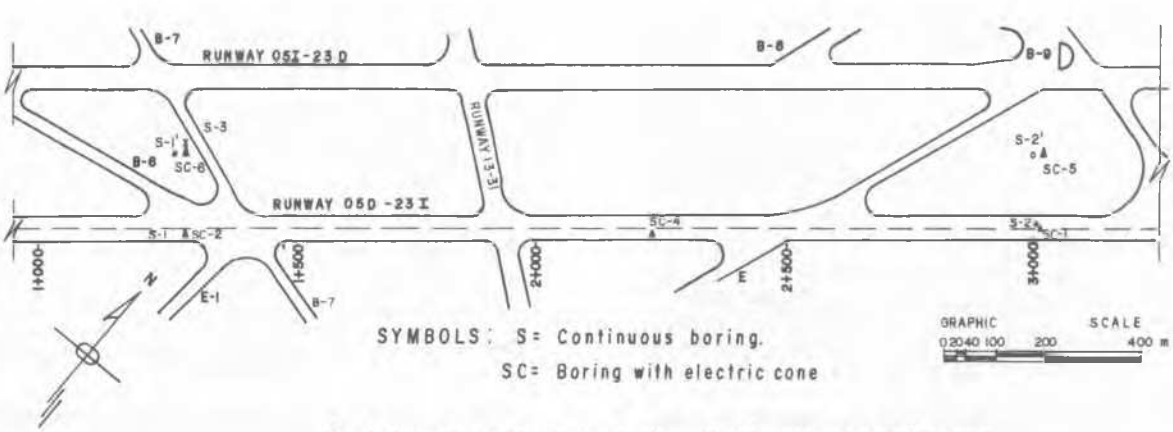


Fig. 1.- Location of borings Mexico City International Airport

3. RESULTS OBTAINED

3.1 Compressibility

Figs. 2 and 3 show four e-log σ'_v curves obtained; the same data is presented in curves log (1+e)-log σ'_v in Figs. 4 and 5. It is interesting to note that similar values of σ'_p can be obtained in both type of curves. In the e-log σ'_v curves, the pseudo-preconsolidation stress was estimated using Casagrande's procedure; in log (1+e)-log σ'_v, it was obtained simply with the intersection of two straight lines fitted to the points graphed.

The values of γ were calculated from all results. In Fig. 6, all γ values are plotted versus liquid limit, w_L, of samples. For comparison, the line proposed by Juárez-Badillo (1975) is shown. It is important to note that no single relationship can be obtained from the points drawn. Furthermore, the authors claim that no such relationship exists. The σ'_p values are plotted versus depth in Fig.7. When comparing these values to the in-situ vertical stresses it is concluded that all strata are preconsolidated. This is in accordance with the results already obtained by Zeevaert (19). It is probable that delayed consolidation be the main cause for this condition.

It is observed, too, that soil is strongly preconsolidated from surface to about 10 m depth.

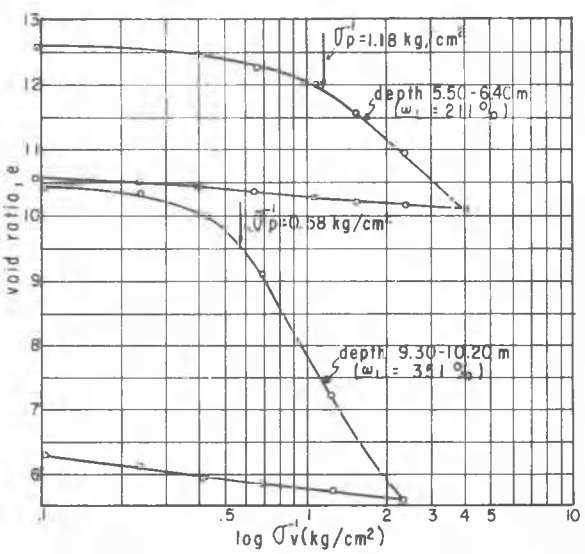


Fig. 2 e versus log σ'_v curves, depth 5.5 - 6.4 and 9.3 - 10.2 m

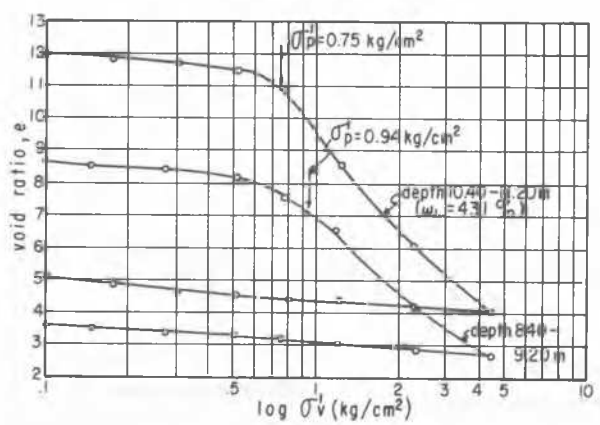


Fig. 3 e versus log σ'_v curves, depth 10.4 - 11.20 and 8.40 - 9.20 m

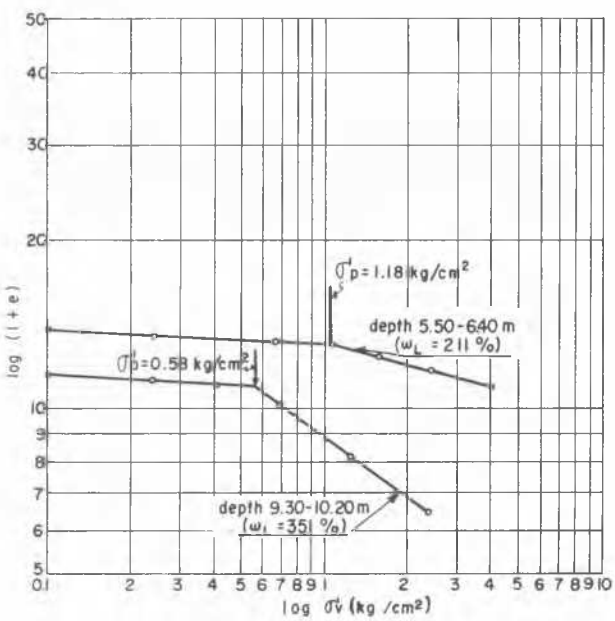


Fig. 4 log (1 + e) versus log σ'_v curves, depth 5.5 - 6.4 and 9.3 - 10.2 m

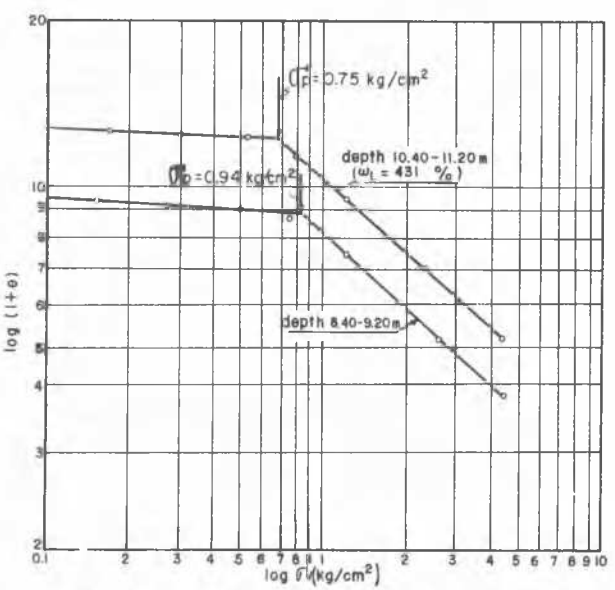


Fig. 5 log (1 + e) versus log σ'_v curves, depth 10.4 - 11.20 and 8.40 - 9.20 m

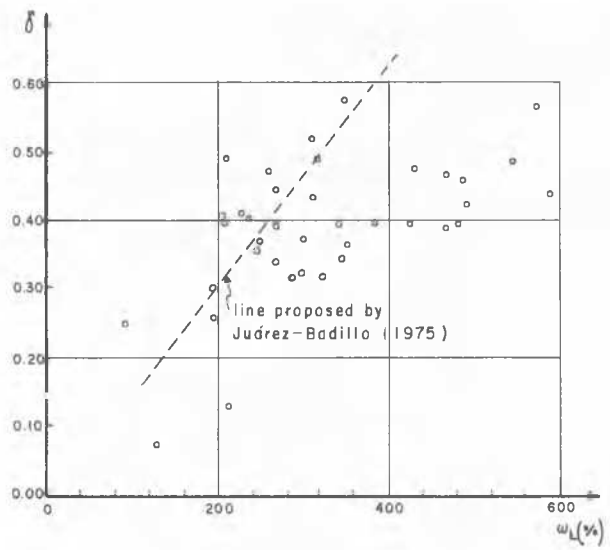


Fig. 6 δ versus ω_L

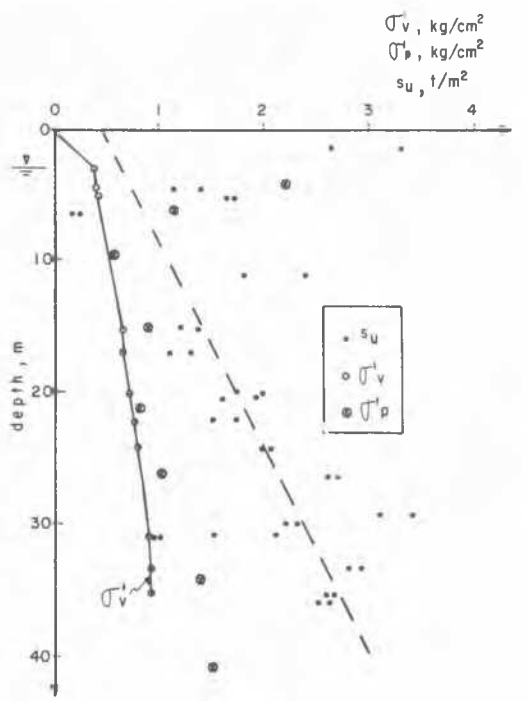


Fig. 7 Values of s_u, σ'_v and σ'_p versus depth

3.2 Strength

The undrained strength, s_u, obtained in all triaxial tests is plotted in Fig.7. A linear relationship can be fitted only between, say 12 to 38 m (the maximum depth at which samples were tested). It can be concluded from this graph that soil is preconsolidated, due to effects other than delayed consolidation, from surface to about 12 m depth. The best fit straight line through points below 12 m crosses the $s_u = 0$ line about 8 m above the surface. The relation s_u/σ'_v varies between 0.22 and 0.29; these values are low as compared with those usually found for similar subsoil. However, it should be remarked that it is usual to find s_u values as low as 1 ton/m2 in this clay.

The cone penetration strength, σ_c obtained in an exploration carried out adyacent to fifth boring is plotted in figure 8. Two well marked tendencies can be observed. The first, near the surface, indicates that soil is preconsolidated down to 5 m depth and the second shows an almost linear increase in strength with depth. It should be emphasized that from 5 to 10 m the σ_c increase with depth is larger than from 11 m down. It is not clear if the differences could be due to different type of material or to the fact that first stratum is preconsolidated. It is supposed this information is not in disagreement with the asevera tion that soil is preconsolidated down to about 12 to 13 m for effects other than delayed consolidation. The σ_c/s_u value varied from 17 to 25. These values are large when compared to those reported in the literature and should be taken as a warning when judging the cone penetrometer results. To sustain this warning it should be said that, in three of five explorations, it was observed σ_c values constant with depth for lengths greater than 10 m.

4. SOME COMMENTS

In the Mexico City International Airport there are two runways. Both have two different structural sections; one is the so-called "compensated section" and the other is the usual type; this last case corresponds to a total length of runway of about 5500 m. The maintenance works in the runways are needed only in the usual type section and consists mainly in an overlayer of asphaltic concrete, 10-15 cm maximum thickness, for restitution of drainage. They are done every two years as at this period of time the runway transversal slope is almost reversed and some freewater is observed after normal rainstorms.

During the last years the question have been arised about the benefits of a preconsolidated layer near the surface in reducing differential settlements. From the observations quoted, it is concluded that, in the Mexico City International Airport, the secondary consolidation effects are greater than the "slab" effect due to a preconsolidated layer of about 11 m near the surface. At this moment, a test program is being carried out about the secondary consolidation and its effects in the runway settlements. It is hoped that a better understanding will be obtained about the phenomenon described before; the results will, hopefully, be applied to other runways constructed on similar subsoils.

5. CONCLUSIONS

All clay strata are preconsolidated down to the maximum depth explored. Two main causes are distinguished: the first is delayed consolidation effect and the second is dessication An upper crust of about 12 m thickness was found to exist at the site.

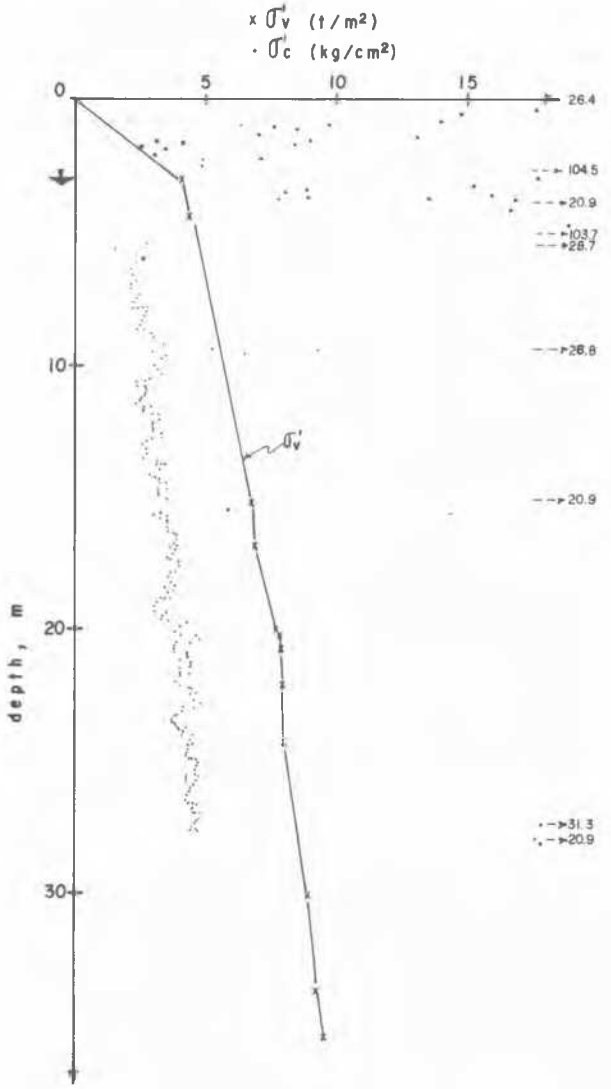
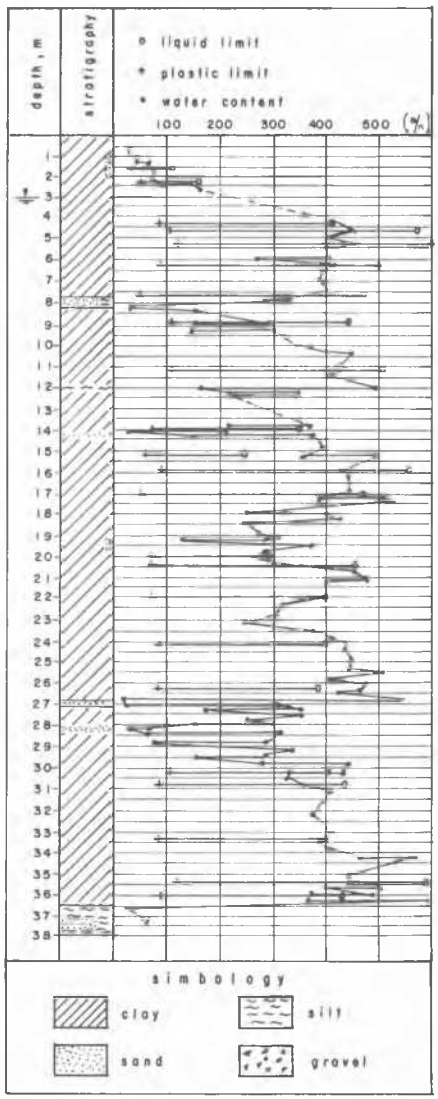


Fig. 8 Values of σ'_c and σ'_v versus depth



No unique relationship was found between γ (slope of the virgin zone in log (1+e) - log σ'_v plot) and w_L.

It was easier to estimate the pseudo-preconsolidation stress, σ'_p, from log (1+e)- log σ'_v plots than from the usual e-log σ'_v plots. The differences between corresponding σ'_p values were small.

The relations s_u/σ'_v and σ_c/s_u found varied between 0.22 and 0.29 and between 17 and 25 respectively.

The first relation, s_u/σ'_v, is low as compared to values found in similar subsoils. The second relation, σ_c/s_u, is large as compared to values reported in literature.

6. ACKNOWLEDGEMENTS

The consolidation results in e-log σ'_v graphs were kindly given by Geosol, S.A.

The participation of Carlos Espino in producing all drawings is strongly appreciated.

7. REFERENCES

Juárez-Badillo, E. (1969), "Pore Pressure and Compressibility Theory for Saturated Clays". Specialty Session N° 12 on Advances in Consolidation Theories for Clays, University of Waterloo, Canada, pp 99-116.

Juárez-Badillo, E. (1975) "Constitutive Relationships for Soils" Symposium on Recent Developments in the Analysis of Soil Behaviour and their application to Geotechnical Structures, Australia, pp 231-257.

Santoyo E. and Olivares, A. (1980) "Penetrómetro Estático para Suelos Blandos" Technical Report, Institute of Engineering, UNAM. Mexico.