

Oedometers tests in compacted tropical soils in the State of Rio de Janeiro, Brazil.

ABSTRACT

Oedometers tests with controlled shear rates were performed in two soils from the Baixada Fluminense region, in the city of São João do Meriti – Rio de Janeiro, Brazil. The soils in question are deposited on non-compacted soft soil with the addition of Municipal Solid Waste (MSW). Both samples of compacted soil were excavated at a depth of 10.0 m, and undisturbed samples were collected. In both tests, the shear rate of 0.043 mm/min was adopted.

Keywords: oedometers, edometric, sand, clay, tension

1. INTRODUCTION

This edometric compression test, commonly called “conventional consolidation test”, is the oldest and best known type for determining soil compressibility parameters. The test consists of the axial compression of a specimen, confined laterally, by applying vertical pressures, with a duration of 24 hours and a predefined load ratio.

2. MATERIAL AND METHODS

2.1 Sample Collection

The experimental ground of study was established in 2010 to study the construction of landfills on layers of non-compacted soft soils with the addition of Municipal Solid Waste (MSW), a common environmental problem throughout the country (Mahler, 2018). Moreover, the region where the samples were collected is in São João do Meriti, located in the Metropolitan Region of Rio de Janeiro (22°47'40.5"S 43°21'05.9"W).

Two undisturbed samples were collected in the field. Point 1 in the slope Region and Point 2 in the Central Region of the development. The samples were 25x25x25 centimeters in size. They were rapidly paraffined and protected, in order to not lose humidity. Therefore, they would not undergo changes during transport to the laboratory, where they were placed in a moisture chamber. For safety factors, Point 1 was chosen for appearing to be more clayey and Point 2 for having higher settlements, as previous mention by Deere e Patton (1971).

2.2 Oedometric

The edometric compression test procedure follows the following steps:

Molding of the specimen with the help of a beveled ring to reduce disturbances in the sample during carving; Placement of the ring, with the soil, in the rigid cell that should contain a porous stone at its base with filter paper, to allow the water to

drain from the specimen; Assembly of the top plate, or "top cap", which should also contain a porous stone; Displacement meter adjustment for vertical displacement measurements; Application of vertical loads in a loading ratio. For this test, the first loading stage was 0.031 (kg/cm²), with 8 loading stages that were applied to the sample, that is, the loading variation was 0.031; 0.062; 0.125; 0.250; 0.500; 1,000; 2,000 and 4,000 (kg/cm²), and three discharging stages 2,000; 1,000; 0.500 (kg/cm²). Each charging stage must last for 24 hours. During each loading stage, vertical compression measurements of the sample are made as a function of time, for times 0, 0.1, 0.25, 0.50, 1, 2, 4, 8, 15, 30, 60, 120 and 240 minutes. With these data, consolidation curves are constructed, that is, displacement versus time. For the case of cohesive soils, the Casagrande Method is used. In the process of consolidation, the dissipation of pore pressures in the sample occurs. Considering that the degree of consolidation of the sample for a given time factor T_v is identical to the average percentage of pore-pressure dissipation, at the end of the consolidation process ($U = 100\%$) the increase in the effective vertical stress along the entire the thickness of the sample will be equal to the total stress increment applied to the top of the sample. With the deformation values, at the end of each loading stage, a curve of the effective stress versus the deformation produced by the increase of this stress is constructed. This curve can be displayed in various ways, such as vertical effective stress versus void ratio, vertical effective stress versus specific volumetric strain.

The DS test was performed in accordance with standard ASTM 2974 soil procedures, to determine the shear stress (Zhao et al, 2014).. Six tests were carried out at two different points in saturated state, with initial tensions of 75 kPa, 150 kPa and 300 kPa for both points. The sample cell has 36 cm² in area (6 cm x 6 cm), is horizontally split and secured by two screws. The adopted shear velocity was 0.043 mm.min⁻¹. The DS tests were carried out with flooding for at least one night.

3. RESULTS AND DISCUSSION

3.1 Oedometric

Table 1 - Informative table with average density coefficient values for the 2 points:

N°	$C_v \times 10^{-3}$	Variation $\times 10^{-3}$
Point 1	37,09 cm ² /s	10,14 cm ² /s
Point 2	40,66 cm ² /s	7,37 cm ² /s

The graphs below show the void ratio vs effective vertical stress curve for the different tests performed (figures 1 and 2):

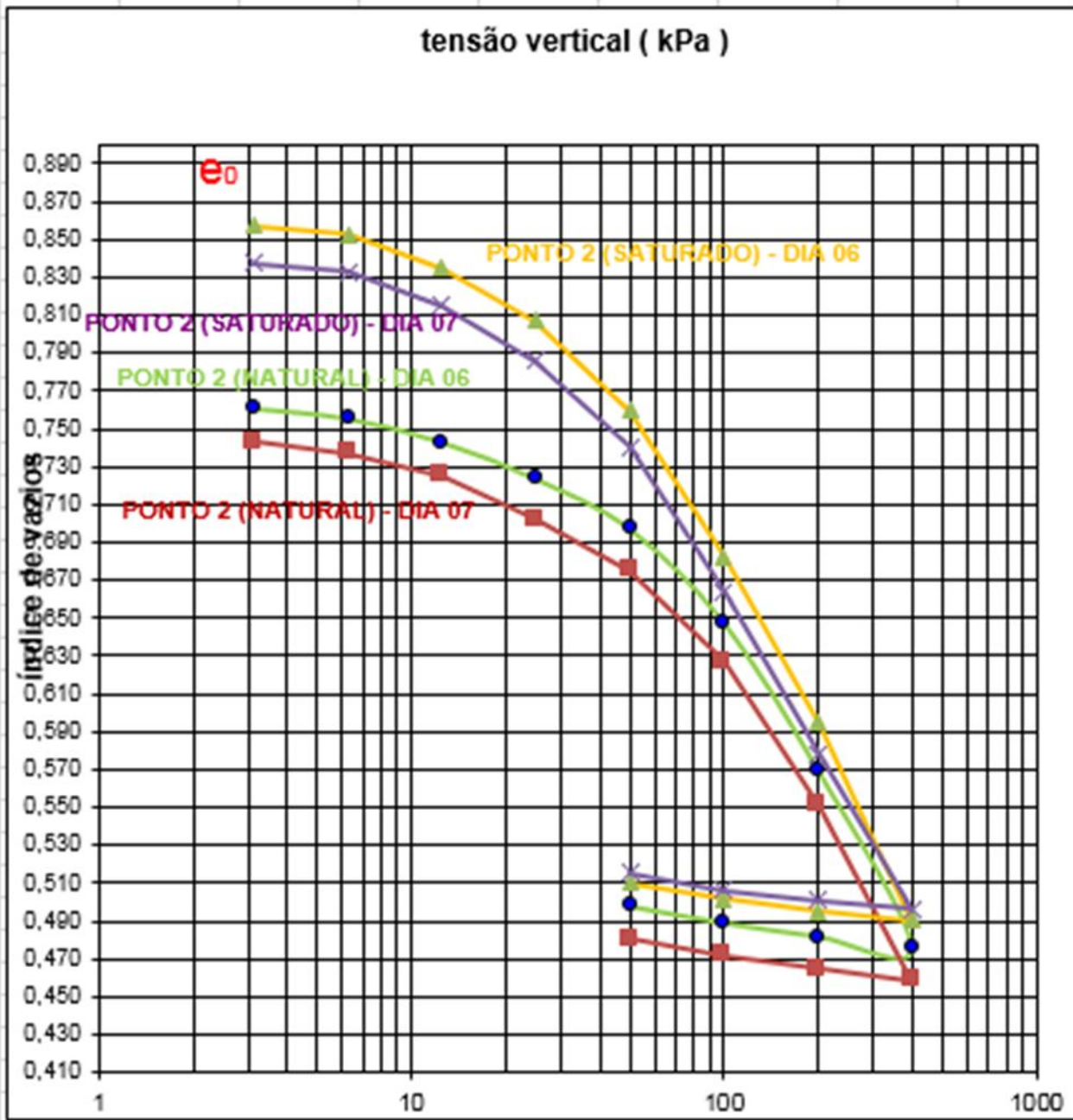


Figure 1: Point 2 - Void Index in the different tests

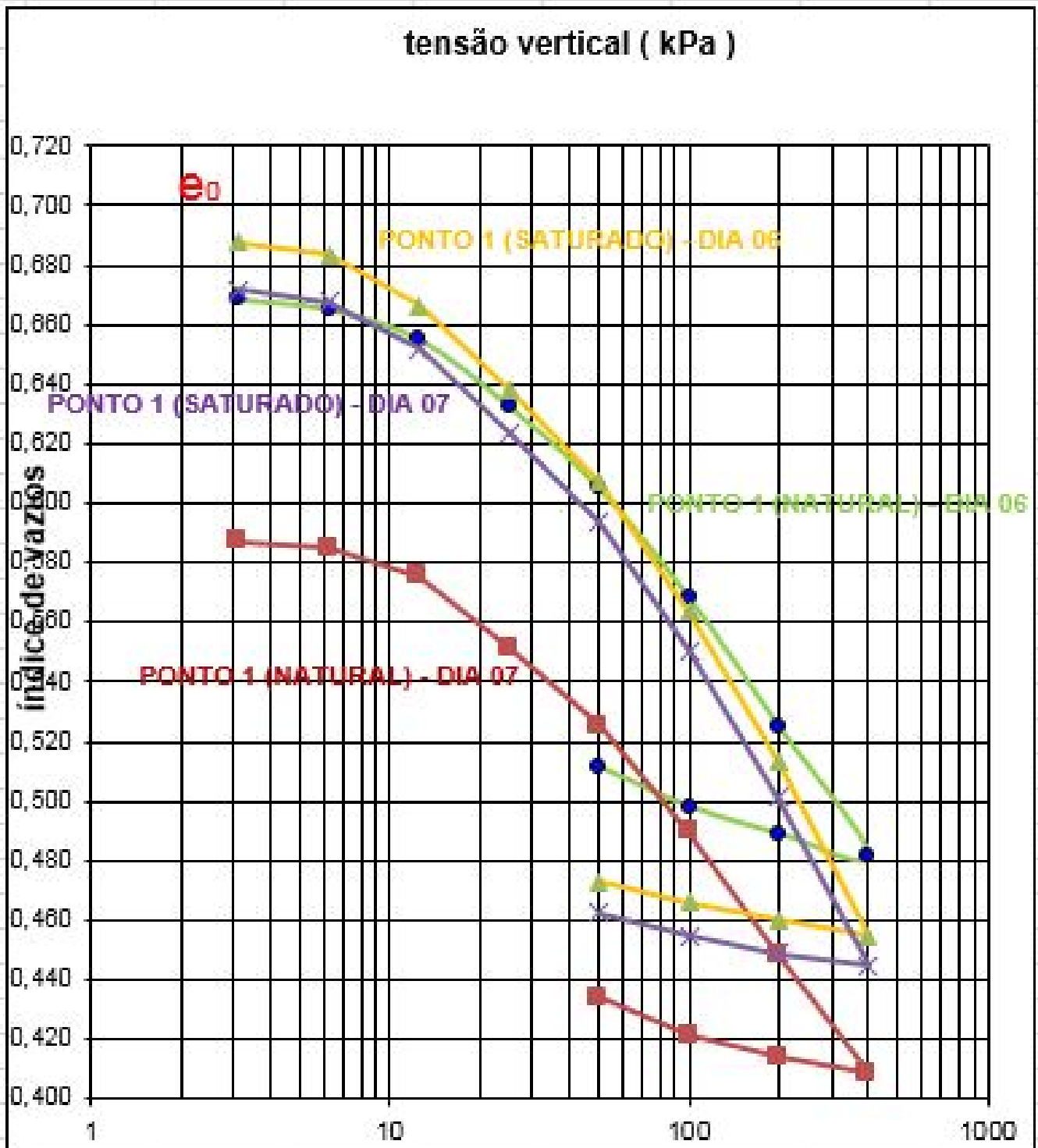


Figure 2: Point 1 - Void Index in the different tests

Nascimento (2008) found very close results for the silty clay of the Canal do Porto da Baixada Santista in the region of Ilha Barnabé, with an average c_v of $79.57 \times 10^{-3} \text{ cm}^2/\text{s}$ and a standard deviation of $27.67 \times 10^{-3} \text{ cm}^2/\text{sec}$.

4. CONCLUSION

In sample/point 1, a final void ratio was observed in the saturated case lower than in the natural case, as expected. The difference between the initial and final voids index in the saturated soil was also greater. The tests carried out can be considered similar to the twins, in which the sample is tested in the natural and saturated state, in order to have a view of the saturation effect, which was proven.

In the case of sample/point 2, the values of the final void index, of the sample tested in the natural and saturated state, are similar. However, the initial values of the voids index of the saturated sample are higher, so that the variation of the voids index in the saturated soil is greater and the greater deformation of the saturated sample was also confirmed.

There was a small difference in the initial moistures of the samples, but not significant.

The compaction coefficient results are typical for soils of this type, with a mean of $39.43 \times 10^{-3} \text{ cm}^2/\text{s}$ and a standard deviation of $15.80 \times 10^{-3} \text{ cm}^2/\text{s}$.

Finally, it is worth noting that all the soils present a certain heterogeneity, which justifies certain differences in the characteristics of the soils collected, although from the same area and subject, in principle, to the same conditions of compaction.

.

REFERENCES

- Andersen, K.H. Cyclic soil parameters for offshore foundation design. Third ISSMGE McClelland Lecture. Frontiers in Offshore Geotechnics III – Volume 1, Oslo, 2015.
- Bjerrum, L. Geotechnical properties of Norwegian marine clays. *Géotechnique*, 4:49-69. 1954.
- Bjerrum, L., Landva, A. Direct Simple-Shear Tests on a Norwegian Quick Clay. *Géotechnique*, v. 16(1), p. 1-20, 1966.
- BS 1377-8 (1990). "Methods of test for soils for civil engineering purposes – part 8: shear strength tests (effective stress)". British Standards Institution, London.
- Bishop, A. W., and D. J. Henkel (1962). *The triaxial test*. London, Arnold
- Casagrande, A.; Hirschfeld, R. C. (1960). Stress- deformation and strength characteristics of a clay compacted to a constant dry unit weight. In: *Research Conference on Shear Strength of cohesive soil*, p.359-417. Boulder, Colorado, USA.
- Coelho, P.A.L.F. (2000). "Caracterização geotécnica de solos moles. Estudo do local experimental da Quinta do Foja (Baixo Mondego)". Dissertação de Mestrado, Dep. Eng.^a Civil da FCTUC, Coimbra
- Coutinho, R. Q.; Bello, M. I. M. C. V. (2011). Analysis and Control of the Stability of Embankments on Soft Soils: Juturnaíba and Others Experiences in Brazil. *Soils & Rocks*, v. 4, p.331- 351.
- Dearman, W. R.; Baynes, F. J.; Irfan, T. Y. Engineering Grading of Weathered Granite. *Engineering and Geology*, 1978, v.12, n.4, p.345-374.
- Dearman, W. R.; Matula, M. Environmental Aspects of Engineering Geological Mapping. *Bulletin of the International Association of Engineering Geology*, Krefeld, 1976, N° 14. p141-146.
- Deere, D.U. and Patton, F.D. (1971). Slope stability in residual soils. *PACSMFE* 4, v. 1, 87-170, Puerto Rico.
- De Mello, V. F. B. (1972). Thoughts on soil engineering applicable to residual

soils. ACSE 13, SASSE, 5-33. Hong Kong

Dyvik, R., Berre, T., Lacasse, S., e Raadim, B. Comparison of truly undrained and constant volume direct simple shear tests. *Géotechnique*, v. 37, n. 1, pp. 3-10. 1987.

Gibson, R. E., and Henkel, D. J. (1954). "Influence of duration of tests at constant rate of strain on measured drained strength," *Geotechnique*, 4(1):6-15.

Head, K.H. (1985). "Manual of soil laboratory testing". Vols. 1, 2 e 3, Pentech Press, London.

Hilf, J. W. (1956). An investigation of pore water pressure in compacted cohesive soils. Technical Memorandum No 654, United States Department of the Interior, Bureau of Reclamation, Design and Construction Division, Denver, CO.

Leao L. A.; Fortes, R. M. Estudo da variabilidade da resistência ao cisalhamento de alguns solos classificados segundo a mct (miniatura, compactado, tropical) para dois níveis de energia: Normal e intermediária. VII Jornada de Iniciação Científica. Universidade Presbiteriana Mackenzie, 2011.

Kavazanjian, E., Jr. Seismic design of solid waste containment facilities. In Proceedings of the 8th Canadian Conference on Earthquake Engineering p. 51-89. Vancouver, BC, June 1999. Google Scholar. 1999.

Kjellman, W. Testing the shear strength of clay in Sweden. *Geotechnique* 2, No.3, p. 225-232. 1951.

Marsal, R. J; Fuentes de la Rosa, A. (1976). Mechanical properties of rockfill soil mixtures, Proc. XII, I cold, Ciudad del Mexico, Mexico.

Mello, V.F.B. "Shearing Strength of clay". Dissertação de M.Sc, MIT, Boston, 1946.

Merighi; J. V.; Alvarez Neto, L.; Fortes, R. M. (1987). Control of soil compaction through the mini- MCV / HILF test. In: XXII Anual Paving Meeting,

Mitchell, J. K.; Sitar, N. (1982). Engineering properties of tropical residual soils. Geotechnical Specialty Conference on Engineering and Construction in tropical and residual soils, ASCE. Honolulu, Hawaii, USA.

Mori, W. (1983). Saprolites compacted in the construction of earth dams and rockfill: the case of the Sossego dam. In: XXV Nacional Conference of Dams, p. 1-18. Salvador, Bahia, Brazil.

Nascimento, V. 2008, "Características de Adensamento da Argila do Canal do Porto de Santos na Região da Ilha Barnabé", Dissertação de Mestrado, COPPE/UFRJ, Rio de Janeiro, Brasil.

Schoder, K. R. "Determinação de Parâmetros Geotécnicos (c' e Φ) de Misturas de Solo Estabilizado por Meio de Cisalhamento Direto e Compressão Triaxial". Dissertação de M.Sc, COPPE/UFRJ, Rio de Janeiro, 2017.

Seed, H.B. e Chan, C. K. (1959). Structure and strength characteristics of compacted clays. *Journal of the ASCE – SM5*.

Simms, P. H. and Yanful, E. K. (2002). Predicting soil-water characteristic curves of compacted plastic soils from measured pore-size distributions. *Géotechnique*, 52, 4, 269 - 278.

Stein, K.; Budny, J.; Hartmann, D.; Tapahuasco, F. C. (2018). Determination of Geotechnical Parameters (c and F) of a lateritic soil with different lime and rice husk ash contents. In: XVI Nacional Conference of Geotechnical / 6as Portuguese-Spanish Geotechnical Day. Ponta Delgada, Portugal.

Vargas, M. (1953). Some engineering properties of residual clay soils occurring in Southern Brazil. *ICSMFE*, 3, v. 1, Zurich.

Vargas, M. (1974). Engineering properties of residual soils from South Central region of Brazil. *ICIACEG*, 2, IAEG, v. IV, 5.1-5.26, São Paulo.

Vargas, M. (1985). The concept of tropical soils. Intl. Conf. on Geomech. In *Tropical Lateritic and Saprolitic Soils*, 1. *ISSMFE*, v. 3, 101-134, Brasília.

Vaz, L. F. (1996). Classificação genética dos solos e dos horizontes de alteração de rocha em regiões tropicais. *Soil and Rocks*, 19 (2), 117-136

Zhao YR, Xie Q, Wang GL et al. (2014). A study of shear strength properties of municipal solid waste in Chongqing landfill, China. *Environmental Science and Pollution Research*, 21(22):12605–12615.

UNDER PEER REVIEW