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Geotechnical Parameters of Soft Soil in Macaé – Rio de Janeiro

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ABSTRACT: This study aims to present strength parameters, compressibility and stress history through a campaign of surveys, piezocone and laboratory tests carried out at two sites in lowland area in Macaé, State of Rio de Janeiro. In this region, there is an extensive deposit of soft soil that mainly due to the development of the oil and gas industry, created a need for new buildings, causing the use of these areas. Moreover, particularly in Macaé, there is little or no information published on the geotechnical parameters. In total 22 holes of SPT, 4 vertical piezocone tests, 2 triaxial tests of unconsolidated undrained type and 5 laboratory oedometer tests were performed. Thus, a set of geotechnical parameters of the deposit was obtained. Additionally, the ratio of over-consolidation are also compared with values from laboratory oedometer tests. The results found showed a reasonable approach between field and laboratory parameters.

1 INTRODUCTION

Along the Brazilian coast it is common to find soft soils in sedimentary deposits formed in the Quaternary period of high compressibility, low permeability, high organic matter content, low bearing capacity and low resistance to penetration. In these deposits piezocone tests have been performed (Danziger and Schnaid, 2000; Coutinho, 2008) as well as in the state of Rio de Janeiro (Almeida & Marques, 2003; Almeida et al 2008a).

This paper presents field test data and laboratory tests carried out in sedimentary deposit in lowland area of Macaé, Rio de Janeiro.

2 DESCRIPTION OF THE AREA OF STUDY

The area of study is the sedimentary deposit of the lowland region located in the North Fluminense, in the city of Macaé, Rio de Janeiro. The coastal region in which Macaé was raised is intensely urbanized. The traffic flow causes major congestion in addition to the environmental issues generated by the lack of basic sanitation, garbage collection and sewage. Due to this urban saturation, the tendency is that the expansion of the city will happen towards the interior, where the soft soil deposit is found.

3 LOCATION OF RESEARCH POINTS

The research points were points of the deposit called: Imbuuro, Linha Verde and Virgem Santa. Typical stratigraphies of these three sites were obtained from 22 survey holes and are shown in Figure 1. The water table in general is quite shallow, at about 0.3 m depth. As these sites are surrounded by rivers or lagoons, the upper layer in many cases is either peat, dredged material, or uncontrolled fills.

Laboratory samples were collected with the help of a stationary piston Shelby tube, following the recommendations of the Brazilian code NBR-9820/1994.

The characterization and laboratory oedometer tests were performed in the region called Imbuuro. The particle size analysis revealed that the analyzed soil consists mainly of fine particles and tested points have similar granulometric characteristics.

The results of the characterization tests are shown in Table 1 while laboratory oedometer tests are shown in Table 2. High values of compression ratio CR observed in Table 2 indicate that the soil is quite compressible and, according to Almeida & Marques (2002), the moisture content of the soil is sensitive in most cases, superior to W_L . This behavior is found in most analyzed samples.

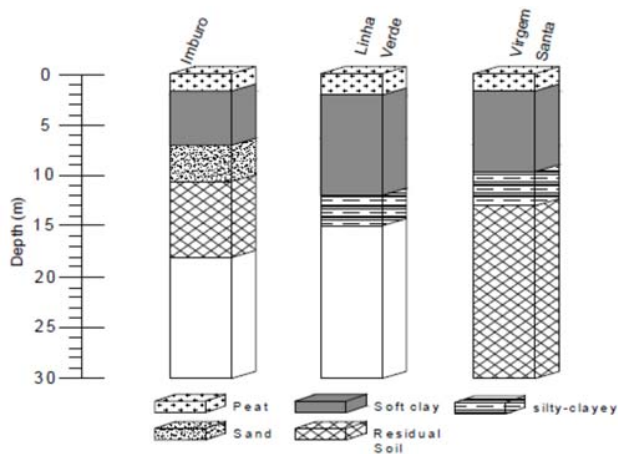


Figure 1. Stratigraphic profile of the investigated points

Table 1. Results of the characterization tests in Imbuuro

Depth (m)	G_s	W_0 (%)	γ (kN/m ³)	e_0
0.15 – 0.75	2.56	80.8	14.9	2.07
1.0 – 1.6	2.56	187.68	12.62	4.84
1.3 – 1.9	2.56	212.47	12.48	5.41
1.5 – 2.1	2.6	189.95	12.74	4.83
2.1 – 2.70	2.62	217.6	12.41	5.7

Depth (m)	W_L (%)	W_p (%)	I_p (%)
0.15 – 0.75	102.5	44.3	58.2
1.0 – 1.6	194	78.4	115.6
1.3 – 1.9	192.9	56.8	136.1
1.5 – 2.1	191.4	62.3	129.1
2.1 – 2.70	165.1	60.2	105

Table 2. Results of the oedometric tests in Imbuuro.

Depth (m)	e_0	C_s	C_c	$CR = C_c / (1 + e_0)$
1.0 – 1.5	4.84	0.2	2.6	0.44
1.5 – 2	4.92	0.3	3.1	0.52
2.1 – 2.7	5.70	0.2	3.0	0.44
2.1 – 2.7	5.65	0.3	3.2	0.48
2.1 – 2.7	5.65	0.2	2.8	0.42
1.3 – 1.9	4.93	0.2	3.0	0.50

4 UNDRAINED RESISTANCE

Unconsolidated undrained triaxial tests were performed in the depths of 1.5 meters and 2 meters in Imbuuro, which resulted in undrained resistance values between 5 and 7,6 kPa. The comparison between the undrained resistance obtained from UU tests in this

study and the undrained resistance found by other authors in sedimentary deposits with similar characteristics in Rio de Janeiro were very similar. It can be mentioned to the values found by Lima & Campos (2014) for the region of Guaratiba - RJ.

5 N_{KT} FACTOR

CPTu tests were performed, two in Linha Verde and 2 in Virgem Santa. Therefore, the data obtained through piezocone tests were used in combination with the results of triaxial undrained tests for the cone factor N_{KT} . The factor N_{kt} is obtained by using the corrected tip resistance (q_t) of CPTu testing and the resistance values of undrained UU triaxial tests, as follows:

$$N_{kt} = (q_t - \sigma_{v0}) / S_u \quad (1)$$

Where σ_{v0} is the total vertical stress.

Since during this work two UU triaxial test were performed in Imbuuro, with 1.5 and 2 meters of depth, they will be used as reference. Therefore, N_{kt} values were calculated in these two depths for every test except piezocone CPT-02, which started at a depth of 2.4 meters. All of the total vertical stress calculations were made by considering the average specific weight.

Figure 2 presents the N_{kt} values calculated in this study and a comparison with N_{kt} values found in other studies. It can be noticed that the found values are consistent with those established in other studies.

6 STRESS HISTORY

A common way to estimate the stress history is through field tests. Among the field tests, the CPTu test can be used to promote an approximation through the equations proposed by Chen and Mayne (1996):

$$OCR = 0.305 (q_t - \sigma_{v0}) / \sigma'_{v0} \quad (2)$$

$$OCR = 0.53 (q_t - u_2) / \sigma'_{v0} \quad (3)$$

It is notable that the equations proposed by Chen and Mayne (1996) estimate much larger OCR values than the expected ones for slightly pre-consolidated clays and significantly greater than the OCR variation found through laterally confined consolidation tests performed in the first experimental program. As the proposed expressions are statistical by nature and for local soils, it is necessary to adjust the results of the expressions with respect to the reference values by correcting the multiplying factor. Therefore, in this work the equations 4 and 5 below were used:

$$\text{OCR} = 0.17 (q_t - \sigma_{v0}) / \sigma'_{v0} \quad (4)$$

$$\text{OCR} = 0.29 (q_t - u_2) / \sigma'_{v0} \quad (5)$$

Figure 3 shows the OCR variation with depth for both of the equations above. It is noted that the OCR determined values show little variation when compared to laboratory results of the experimental program in Imbuuro.

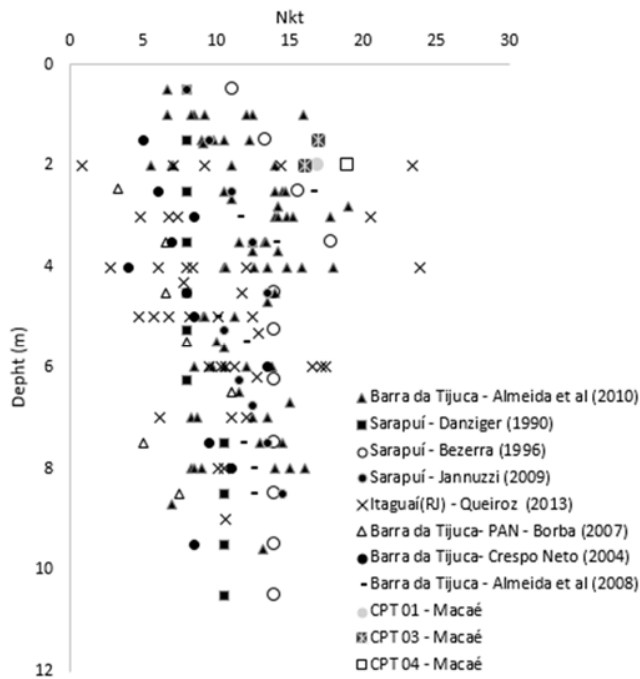


Figure 1 - Factor N_{KT} for the soft soil deposits in Rio de Janeiro

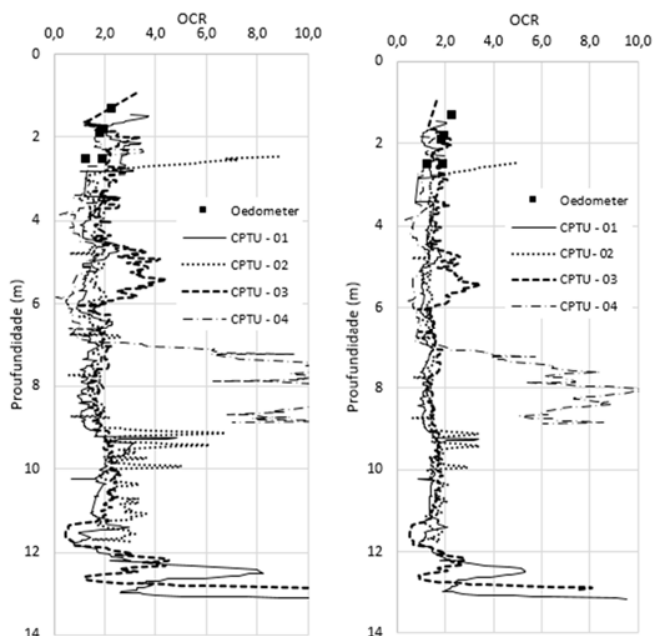


Figure 2. Approximation of vertical consolidation coefficient, CPT 01 and CPT 03.

7 CONCLUSION

The results of laboratory and field tests conducted in sedimentary deposits along the Brazilian coast have been widely used as a reference for geotechnical projects in areas with similar characteristics. However, it seems that due to the high variability of parameters, they are fundamentally guiding and do not eliminate the need for geotechnical field and/or laboratory research in analysis of cases related to specific edifications.

The SPT boreholes profiles, stratigraphy and compression parameters are similar, as simple as Atterberg limits are a bit different. The average value of the empirical factor N_{kt} of cone (17) obtained through the CPTu tests revealed values that are similar to those soft soil deposits found in Rio de Janeiro. The OCR values indicated that the deposit is slightly pre-consolidate.

8 ACKNOWLEDGEMENTS

Rio de Janeiro Foundation for the Support of Research, FAPERJ.

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