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# Behaviour of displacement, cast-in-place piles on collapsible soil

## Analyse du comportement de pieux fabriqués sur place dans sols effondrables

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**ABSTRACT:** The paper presents the results of instrumented compression load tests carried out in three uncased cast-in-place piles (pounded piles, called “apiloadas” in Brazil) which is largely used in interior part of the state of São Paulo. The tests were conducted with the soil in the natural condition and after soaking with water, before loading, in order to evaluate the influence of the soil collapsibility in the results. The values of the ultimate loads (total, point and lateral loads) obtained in the tests are presented and compared with the values predicted by empirical methods that utilize SPT and CPT results.

**RÉSUMÉ:** Cet article expose des résultats des essais statiques sous charge axiale pour trois pieux pilonnés et instrumentés. Cela est justifié par le fait que ce type de pieu est largement utilisé dans une partie d'état de São Paulo-Bresil. Les essais statiques ont été réalisés tout d'abord en terrain naturel et après prenant en compte l'inondation du terrain. Cette technique a été utilisée avec le propos de vérifier l'influence d'un sol effondrable sur les résultats expérimentaux. Les valeurs de la charge ultime (frottement latéral plus la charge en pointe) obtenues en place sont comparées à celles calculées par des méthodes empiriques en utilisant des résultats de SPT et CPT.

### 1 INTRODUCTION

The region of Bauru, in the center of São Paulo state in Brazil, is typically underlain by sandstone of Bauru Group. The topmost soil is residual, constituted by a clayey fine sand. Figures 1(a) and 1(b) present the variation with depth of the values obtained in the penetration tests (N) and the torque measured in SPT-T tests. Figures 1(c) and 1(d) present the variation with depth of the values measured in the cone penetration tests (cone resistance and the lateral friction).

The average specific gravity of the soil is  $1.770 \text{ kg/m}^3$ , the average void ratio is 0.67 and the natural water content ranges from 8 to 15%. The liquid limit is 22 % and the plasticity limit is 16 %. Triaxial tests (CU) performed show cohesion intercept ( $c'$ ) near 15 kPa and friction angle ( $\phi'$ )  $30^\circ$ .

This type of soil, with high porosity, and normally deep ground water level, allows the execution of a cast-in-place uncased pile where the soil, instead of excavated, is displaced by a free drop of a cylindrical hammer with mass ranging from 300 to 600 kg. The soil near the shaft is compacted and creates a kind of firm soil ring that supports the shaft before concreting takes place.

Although this pile type is largely used, the estimate of the ultimate load is made by empirical methods using Cone Penetration Test or Standard Penetration Test results.

Lobo et al.(1991) and Agnelli & Albiero(1994) demonstrated, based on pile load tests and plate load tests, that the local soil is collapsible, and this was confirmed in consolidation tests.

In order to evaluate the ultimate load capacity of this type of pile, a research program was conducted in the experimental field of the UNESP (São Paulo State University), campus of Bauru, where 250 mm diameter pounded piles were tested in compression. These tests (QML) ave been conducted using instrumentation (load cell and electrical strain gages), with the soil in the natural condition and after soaking with water for 72 hours, before loading.

### 2 PILE LOAD TESTS

Figure 2 shows the load settlement curves for the piles in the first and second load test, conducted with the soil in the natural condition and the third load test after soaking the soil, and the load transfer curves where the load carried by the shaft and the point load of the pile can be evaluated in the first load test.

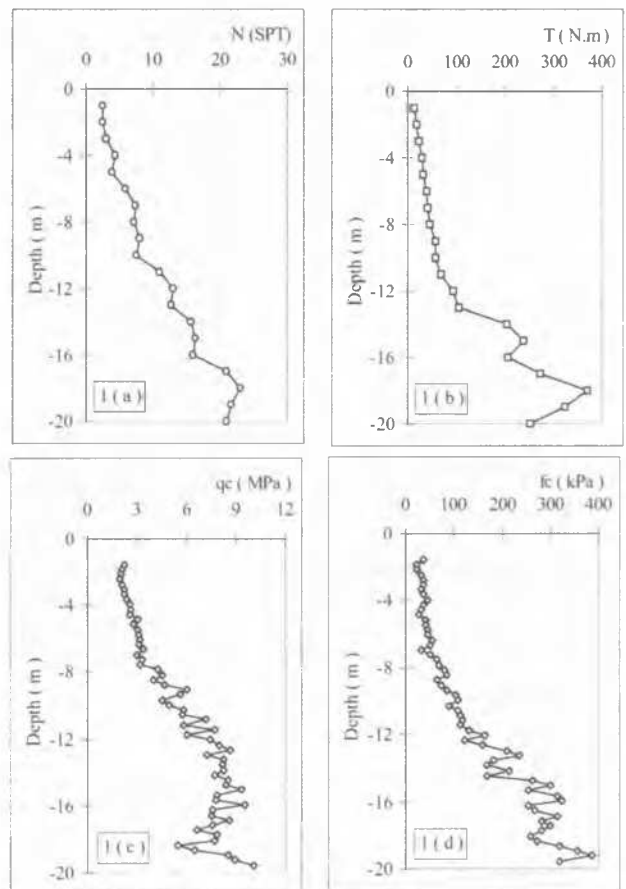


Figure 1. SPT-T and CPT tests results.

Figure 3( a ) shows the load-settlement curve in the first load test. Figure 3( b ) shows the variation of the ultimate load with length of the piles tested. For the 4m length, the ultimate load was 104kN, for the 7m length, it was 216kN and for the 10m length, the ultimate load was 320kN.

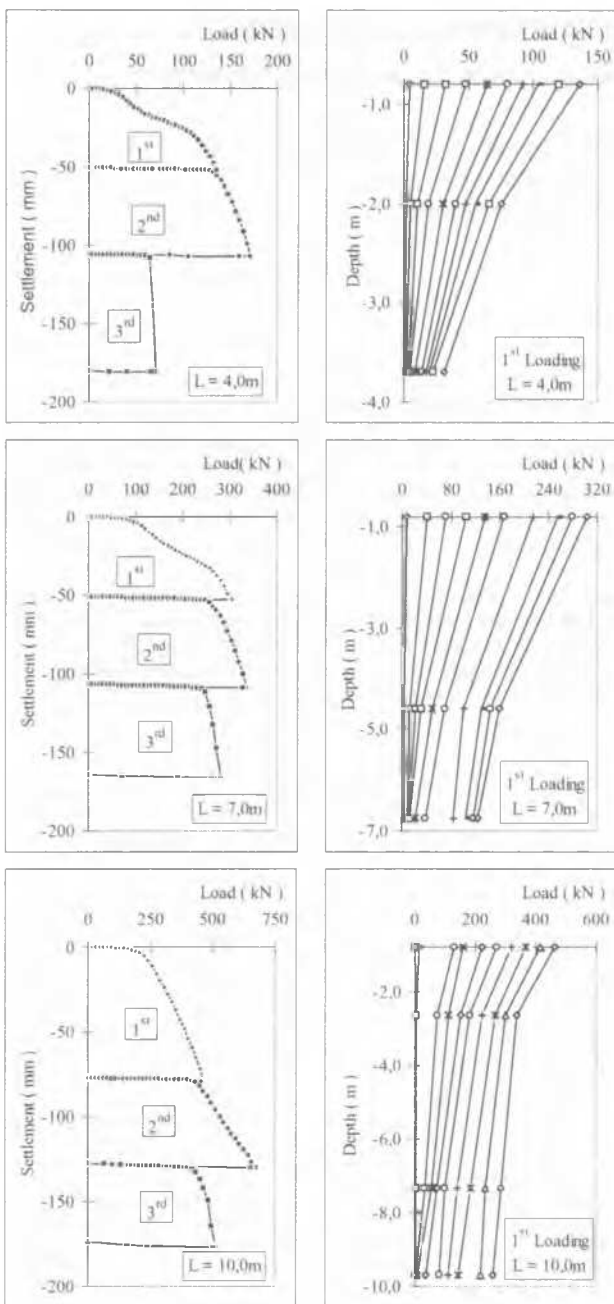


Figure 2. Load displacement curves and load transfer curves.

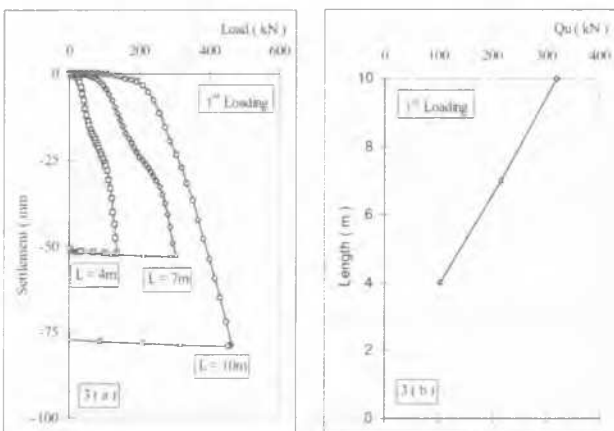


Figure 3. Load settlement curves and variation of the ultimate load with length of the piles tested, in the first load.

The analysis of the instrumentation's results and the application of Cambefort laws show that the ultimate load occurs at 27mm for the 4m pile, 26mm for the 7m pile and 27mm for the 10m pile, in the first load tests.

### 3 ANALYSIS OF THE RESULTS

The analysis of figure 2 show that the load carried by the shaft, in the first load test, was: 84kN; 131kN and 210kN for the 4, 7 and 10 meter length piles and the point load was 20kN; 85kN and 110kN.

The influence of the soaking of the soil, in the load capacity of the piles were evaluated after analyzing the first, second and third load test results. For the 4m length pile, it was determined that a loss of capacity was near 60% and for the 7m and 10m length, the loss was near 30%.

Table 1 compares the prediction of the ultimate load in the first load test, using Décourt-Quaresma (1978), based on SPT results and Aoki-Velloso (1975) based on CPT results utilizing parameters F1 and F2 of the pre-cast concrete pile.

Table 1. Comparison of the ultimate load.

	L = 4m	L = 7m	L = 10m
Aoki-Velloso	99	138	252
Décourt-Quaresma	109	223	335
Load Tests	104	216	320

### 4 CONCLUSIONS

The settlements corresponding to the ultimate load, in the first load test, are very close to 10 % of the diameter of the pile and near 1 inch which are in accordance with some recommendations methods .

The load capacity of this inexpensive type of pile shows that it can be a good foundation solution for small and medium construction in this large region. The influence of the soaking is of the same order of that for other type of foundation in this soil and that it is very important to consider this fact in foundation design in loose unsaturated sandy soil.

### REFERENCES

- Agnelli, N. & Albiero, J.H. 1994. Efeito da colapsividade no resultado de provas de carga diretas. *X Congresso Brasileiro de Mecânica dos Solos e Engenharia de Fundações*:167-174, Foz do Iguaçu.
- Albiero, J.H., Carvalho, D. & Lobo, A.S. 1993. *Solos do interior de São Paulo*. Capítulo 9 - Fundações: 243-275. São Carlos EESC-USP/Associação Brasileira de Mecânica dos Solos.
- Aoki, N. & Velloso, D.A. 1975. An approximate method to estimate the bearing capacity of piles. *Proc. 5<sup>th</sup> PAMCSMFE*: 367-376, Buenos Aires.
- Décourt, L. & Quaresma, A.R. 1978. Capacidade de carga de estacas a partir de valores do SPT. *VI Congresso Brasileiro de Mecânica dos Solos e Engenharia de Fundações*:45-53, Rio de Janeiro.
- Ferreira, C.V. Albiero, J.H. & Lobo, A.S. 1991. Características geotécnicas do solo residual de arenito da cidade de Bauru. *II Seminário de Engenharia de Fundações Especiais*: 133-142, São Paulo.
- Lobo, A.S.; Albiero, J.H. & Ferreira, C.V. 1991. Influência da inundação na carga última estacas de pequeno porte. *II Seminário de Engenharia de Fundações Especiais*:217-226, São Paulo.
- Massad, F.1991. Análise da transferência de carga em duas estacas instrumentadas, quando submetidas a compressão axial. *II Seminário de Engenharia de Fundações Especiais*, pp.235-244, São Paulo.