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FLAT DILATOMETER TEST FOR CHARACTERIZATION AND PREDICTING SETTLEMENTS IN A SANDY SOIL SITE

ENSAIO DE DILATÔMETRO PLANO PARA CARACTERIZAÇÃO E PREVISÃO DE RECALQUES EM UM LOCAL DE SOLO ARENOSO

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RESUMO: Qualquer obra civil, ao ser carregada, recalcará, sendo, portanto, necessária a previsão dos recalques da estrutura a ser projetada. Assim, é necessário conhecer do módulo de deformabilidade do solo (E_s). Entretanto, a sua determinação em solos arenosos é complexa, devido a dificuldade em se obter amostras indeformadas para ensaios de laboratório, além da variação da deformabilidade do solo com o nível de tensões, ou seja, com a profundidade. Deste modo, os ensaios de campo, como o Dilatômetro Plano (DMT), exercem papel de destaque na definição de parâmetros de deformabilidade em areias. Neste sentido, este artigo apresenta e discute resultados de quatro ensaios DMT realizados em um perfil de solo arenoso localizado no câmpus experimental da Unesp de Bauru. A partir desses resultados, fez-se a classificação do tipo de solo e a estimativa de parâmetros de projeto a partir de correlações, os quais foram comparados com valores de referência. Além disso, estimou-se o recalque por meio da abordagem elástico-linear tradicional e comparou-se os resultados com ensaios de prova de carga em placa (PLTs) previamente realizados neste local a 1,0, 2,0, 3,0 e 4,0 m de profundidade. O ensaio DMT se mostrou uma técnica eficiente na caracterização do perfil de solo estudado bem como na previsão de recalques. Constatou-se também, que em solos não saturados, como o perfil de solo estudado, há necessidade de se considerar o efeito da sucção na interpretação de ensaios de campo, uma vez que o comportamento mecânico desses solos é influenciado por ela, afetando as previsões de comportamento mecânico do solo.
Palavras-chave: DMT. Estimativa de recalque. Investigação do subsolo. Módulo confinado. Solos arenosos.

ABSTRACT: When loaded, civil engineering works settle, thus making it necessary to estimate and analyze the settlements of the designed structure. To estimate these values, it is necessary to know the modulus of deformability of the soil (E_s), but its determination in sandy soils is complex, as obtaining undisturbed samples in these soils is a challenging task. Therefore, in situ tests, such as the Flat Marchetti Dilatometer (DMT), are interesting tools for this purpose. This paper presents and discusses the results of four DMTs carried out on a profile of clayey fine sand located on the Unesp Experimental Research Site in Bauru. The soil type was classified based on these results and the design parameters were estimated using correlations, which were compared with reference values. The settlement was then estimated using the traditional elastic-linear approach and were compared with plate load tests (PLTs) previously carried out on at this site at 1.0, 2.0, 3.0 and 4.0 m depths. The DMT proved to be an efficient tool for characterizing the soil profile studied. It was also found that in unsaturated soils, there is a need to consider the effect of suction when interpreting in situ tests, as the mechanical behavior of unsaturated tropical soils is strongly influenced by it, affecting predictions of the soil's mechanical behavior.
Keywords: DMT. Settlements estimation. Site investigation. Constrained modulus. Sandy soils.

INTRODUCTION

Uncertainties associated with the soil formation process and the variability of unsaturated soil profiles emphasize the need for a good investigation plan that is specific to each case, using in situ and laboratory tests, both to create the subsoil profile and to estimate design parameters.

The application of a vertical load to a shallow (footing) or deep (pile) foundation will cause deformations in the soil. These deformations correspond to the vertical downward displacement of the base of the foundation is about a fixed and undisplaceable reference, such as the top of the rock. Settlement is the result of deformation due to a reduction in volume and/or a change in the shape of the soil mass between the base of the foundation and the undisplaceable (Cintra et al., 2011).

The prediction of settlements in sandy soils is a complex procedure, due to the difficulty in obtaining undisturbed samples for laboratory tests, as well as the variation in the soil's deformability with the level of stress acting. In situ tests, such as the Marchetti Dilatometer Test (DMT), are therefore important for defining deformability parameters in sands, as they can be used to apply empirical correlations to define this parameter and consequently estimate soil settlement (Rocha et al., 2021a; Rocha et al., 2021b; Saab et al., 2023).

The plate load test (PLT) is a classic experimental method for predicting immediate settlement in footings. The most appropriate way to define the characteristics of the stress-settlement curve is by carrying out these tests (Décourt & Quaresma Filho, 1996). However, performing such tests is costly, time consuming and requires special equipment, which makes this procedure difficult to incorporate into geotechnical engineering practice.

Predicting the settlement of shallow foundations is probably the main application of the DMT test. Available experience (Leonards & Frost, 1988) generally indicates that there is satisfactory consistency between the measured settlements and those estimated from the DMT test.

This article presents and discusses the comparison between settlement obtained in 0.805 m diameter plate load tests carried out at 1.0, 2.0, 3.0 and 4.0 m depth and estimated from the DMT test, in a tropical sandy soil profile from the Unesp Experimental Research Site in Bauru, as well as the geotechnical characterization of this profile by analyzing the results of the DMT tests with laboratory tests

BACKGROUND

DMT

The Marchetti Dilatometer Test (DMT) was developed by Professor Silvano Marchetti in the 1970s, with the initial purpose of determining deformation modulus for the design of pile foundations subjected to horizontal loads (Marchetti, 1980). However, due to its simplicity, the possibility of correlating the pressure measurements determined in the test with various geotechnical parameters was identified, encouraging its dissemination both in research and in practice.

The dilatometer consists of a flat stainless-steel sheet 14 mm thick, 95 mm wide and 220 mm long, with a flexible membrane 60 mm in diameter positioned on the face of the sheet. The other components of the system are a control unit and electrical and pneumatic cables. The test layout is shown in Figure 1.

The DMT consists of driving the blade into the ground (typically at 200 mm intervals) and determining the pressures required to displace the metal membrane so that it loses contact with the sensitive equipment (reading *A*), the pressure required to cause a displacement of 1.1 mm (reading *B*) and the pressure remaining after the gas is released (reading *C*). The interpretation of the DMT begins with the calculation of the three intermediate parameters (I_D, K_D and E_D). The material index (I_D – Equation 1) is calculated to identify the type of soil. The horizontal stress index (K_D – Equation 2) provides the basis for various correlations for parameter estimation. The dilatometer modulus (E_D – Equation 3), on the other hand, should be used in conjunction with I_D and K_D, due to the lack of information on the stress history (Marchetti et al., 2001).

$$I_D = \frac{p_1 - p_0}{p_0 - u_0} \qquad (1)$$

$$K_D = \frac{p_0 - u_0}{\sigma'_v} \qquad (2)$$

$$E_D = 34.7 * (p_1 - p_0) \qquad (3)$$

where:

p_0 and p_1 – are the pressure readings (*A* and *B*) corrected for membrane stiffness (Marchetti et al., 2001);

u_0 – hydrostatic pressure, kPa;

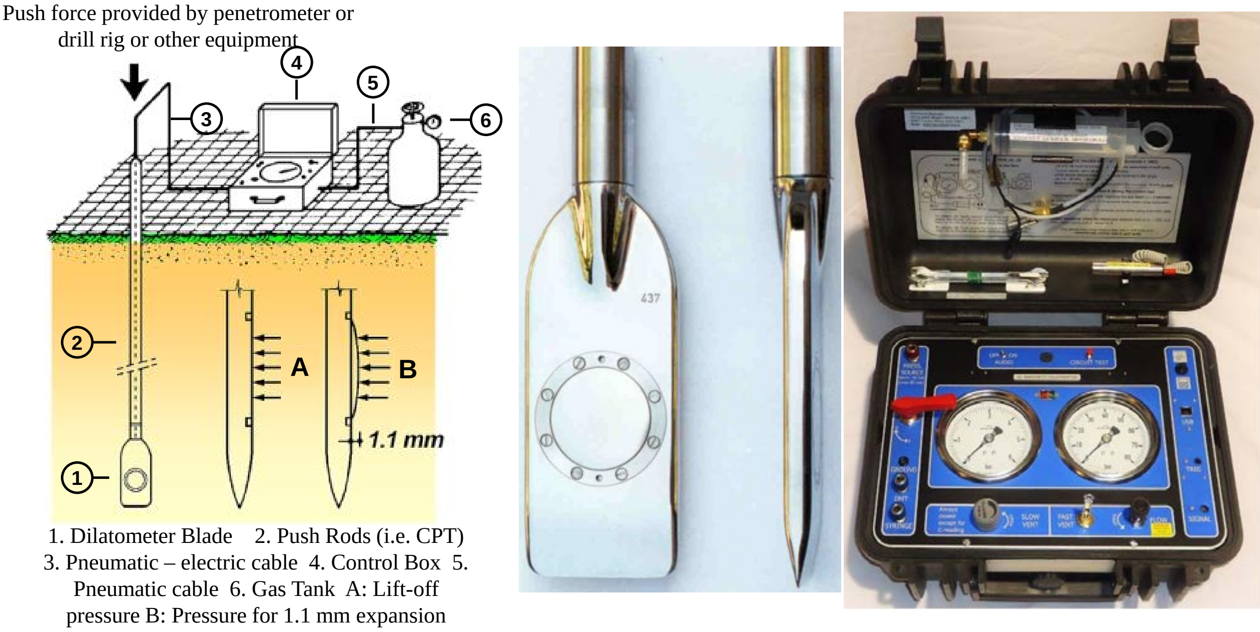
σ'_v – effective vertical stress, kPa.

Predicting Settlements by DMT

Predicting settlements of shallow foundations is probably the main application of the DMT, especially in sands, where undisturbed sampling and estimating compressibility are particularly difficult (Marchetti et al., 2001).

Settlement can be estimated via DMT using the Confined Modulus (M_{DMT}), defined as the ratio between the variation in effective vertical stress and axial deformation ($M = \Delta\sigma'_v/\Delta\epsilon$). M_{DMT} is obtained from the dilatometric modulus E_D, using Equation 4.

$$M_{DMT} = R_M * E_D \quad (4)$$



a) b) c)

Figure 1 – a) General layout of the dilatometer test; b) Dilatometer blade; c) Control box (adapted from Marchetti et al., 2001).

R_M is a correction factor that depends on I_D and K_D, which is necessary because E_D is obtained from the soil deformed by the penetration of the blade and the direction of loading is horizontal, while M_{DMT} is vertical, determined according to Table 1.

Table 1 – Correction factor (R_M) adapted from Marchetti et al. (2001)

$I_D \leq 0.6$	$R_M = 0.14 + 2.36 * \log K_D$
$I_D \geq 3.0$	$R_M = 0.50 + 2.0 * \log K_D$
$0.6 \leq I_D \leq 3.0$	$R_M = R_{M,0} + (2.5 - R_{M,0}) * \log K_D$, with $R_{M,0} = 0.14 + 0.15 * (I_D - 0.6)$
$K_D \geq 10$	$R_M = 0.32 + 2.18 * \log K_D$
$R_M < 0.85$	Set $R_M = 0.85$

In addition, E_D does not provide information on the stress history, which is of great importance in settlement analysis (Marchetti et al., 2001).

Settlement calculation using the DMT is based on the traditional (unidirectional) elastic-linear approach, where the stress increments ($\Delta\sigma$) are calculated using the theory of elasticity (Boussinesq) and the modulus of deformability is determined using the DMT test.

Marchetti et al. (2001) recommend calculating the settlement of shallow foundations using Equation (5):

$$S_{DMT} = \sum \frac{\Delta\sigma_v}{M_{DMT}} \Delta z \quad (5)$$

where:
$\Delta\sigma$ – stress increase;
Δz – depth increase.

The vertical stress increment and the confined modulus determined by the DMT (M_{DMT}) are assigned to each calculation interval (typically 0.20 m). Poisson's ratio (n) and horizontal stress are not required with this calculation method. Settlement calculations from the DMT were carried out using software developed by Studio Prof. Marchetti, available at https://www.marchetti-dmt.it/instruments/software/. The DMT Settlements Software computes the one-dimensional conventional settlements calculation below uniformly loaded surface areas of flexible loads using the DMT results. The software is designed to import from *.UNI* files the constrained modulus of the soil and the vertical effective stress from the DMT. In addition, the software automatically generates a word document composed of a summary page with input and main results, graphs and tables.

Several studies have discussed the applicability of the DMT test in the prediction of settlements in shallow foundations. Monaco et al. (2006), by compiling studies on measured and estimated settlement values based on DMT test results, found that the average ratio between estimated and measured settlements was approximately 1.3, proving reasonable agreement, and thus the use of the DMT test for this purpose.

Plate Load Tests (PLTS)

The determination of the load bearing capacity and estimation of immediate settlement in shallow foundations can be carried out using plate load tests (PLTs). This test, which follows NBR 6489 (ABNT, 2019), consists of the installation of a 0.805 m diameter metal plate, at the design level of the foundation base, and the application of load, in stages, with simultaneous measurement of settlements. The purpose of this test is to evaluate the behavior of the foundation under the action of forces coming from the superstructure, and its settlement level will depend on the needs of each project (Menegotto, 2004).

The test provides satisfactory results in soils where the mobilized settlements are practically immediate, such as sandy soils and clayey soils with a low degree of saturation. During the test, the settlements measured for each stage must reach stabilization, especially in structures where the admissible settlement criteria are the constraints for the project (Cintra et al., 2011).

The test requires the use of a reaction system, which transfers the load applied by the hydraulic jack to the metal plate. Figure 2 shows a general scheme for carrying out plate load tests.

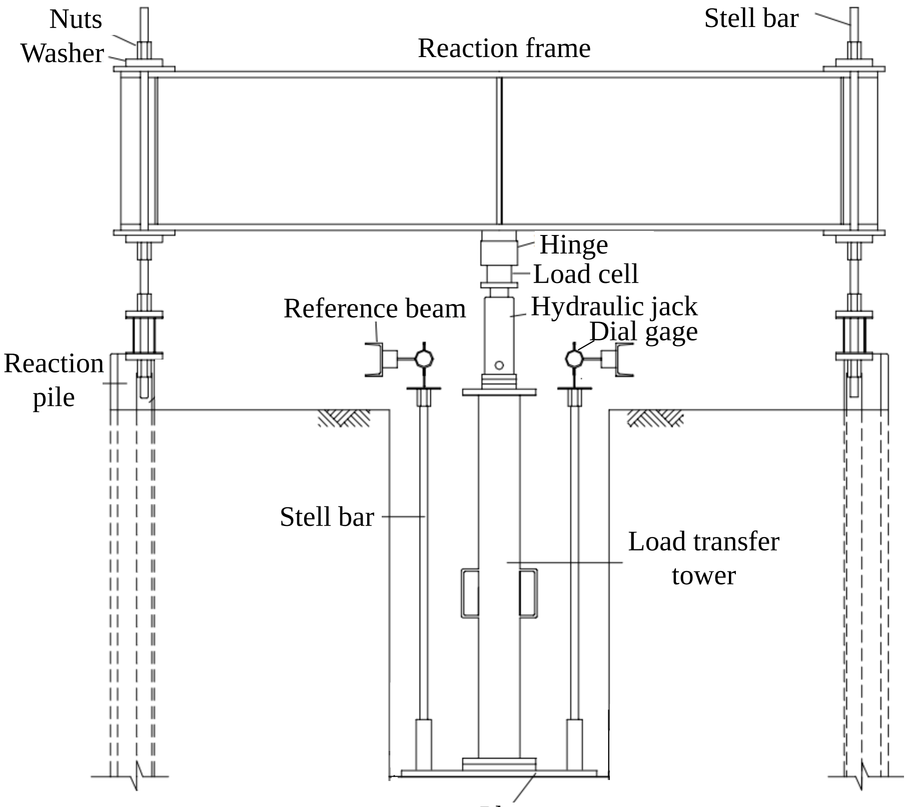


Figure 2 – Schematic representation for the Plate load tests (PLTs) (adapted from Costa, 1999).

Study site

The tests were carried out at the Unesp Experimental Research Site in Bauru, a city located 320 km northwest of the capital of the state of São Paulo. The geotechnical profile that occurs at the site is composed of a clayey red fine sand, classified as SM soil by the Unified Soil Classification System, which is unsaturated up to a depth of around 20.0 m. In the first 13.0 m, the soil shows lateritic behavior, classified as LA' soil in the MCT. From this depth onwards, the soil shows non-lateritic behavior, classified as NA'.

These soils are characterized by partly saturated high-permeability (10^{-5}–10^{-6} m/s) soils, cohesive-frictional behavior as well as the collapsible behavior upon wetting.

Another important aspect at this site refers to the horizontal variability of the soil's behavior, which is evident when analyzing, for example, the q_c records in tests with the electric CPT, which were discussed by De Mio (2005).

A comprehensive site characterization program including standard penetration (SPT), cone penetration (CPT), downhole (DH), and seismic cone (SCPT) tests were carried out at the site. A sample pit was excavated to retrieve disturbed and undisturbed soil blocks.

These blocks were tested in the laboratory to characterize the soil and to determine specific mechanical properties.

Figure 3 shows a representative soil profile and a summary of laboratory and in situ tests. The typical soil profile was defined based on the SPT, and it is presented in Figure 3a together with SPT *N*-values (Figure 3b). *N*-values from SPTs increase almost linearly in depth, up to 13.0 m depth. The cone resistance (q_c) and the friction ratio (R_f) presented higher value at the top 1.0 m and tended to increase with depth leading to R_f between 1 and 3 % and q_c between 3 and 10 MPa. Figure 3e shows the variation of *Vs* values with depth determined by SCPT and DH.

The void ratio (*e*) at 1.0 m depth is equal to 0.72 and drops to about 0.60 at 16.0 m depth, while the dry unit weight (γ_d) at 1.0 m depth is equal to 15.64 kN/m^3 and increases with depth (Figure 3f).

Grain size distribution for the soil samples retrieved every meter from one of the SPTs were defined using dispersant (Figure 3g).

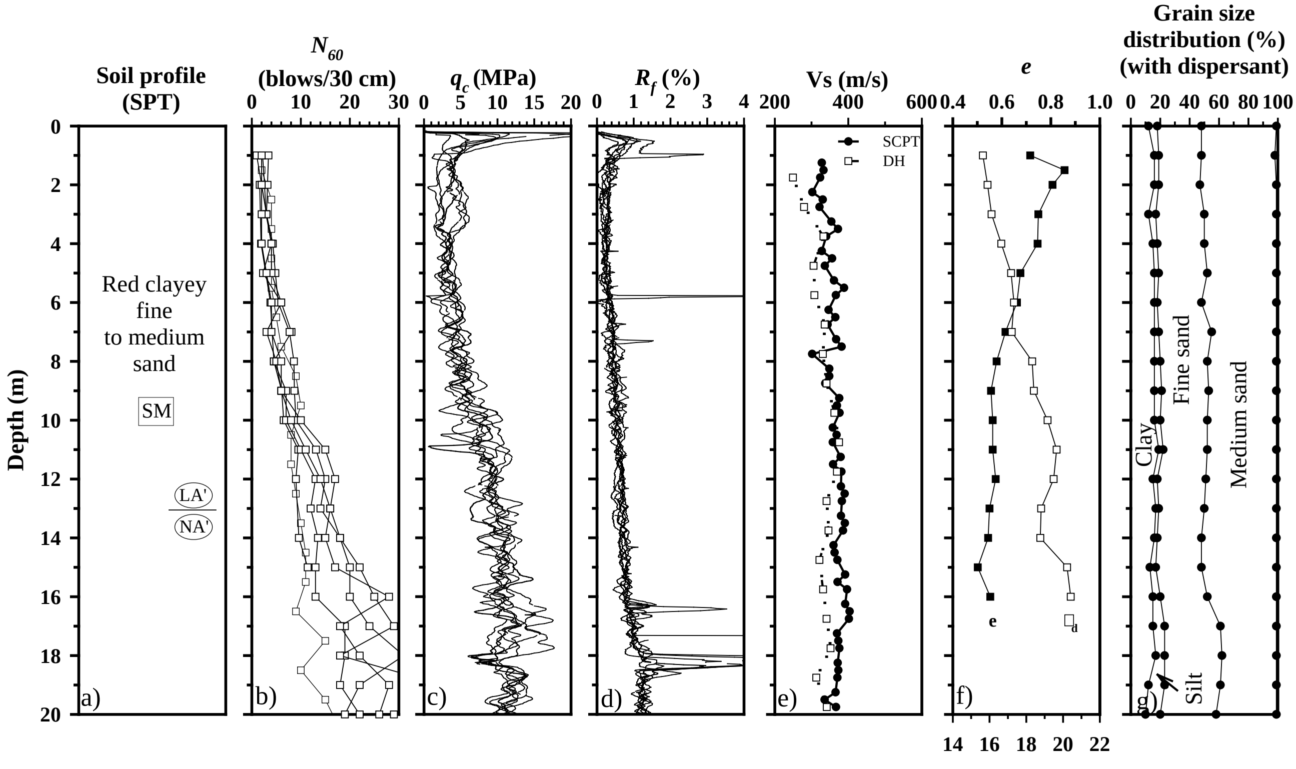


Figure 3 – Synthesis of in situ and laboratory test data for the Unesp Research Site (adapted from Rocha & Giacheti, 2018)

MATERIALS AND METHODS

DMT Tests

Four DMT were carried out at the Unesp Experimental Research Site in Bauru to a depth of 16.0 m. This allowed the determination of the variation profiles with depth of the intermediate parameters (I_D, K_D, E_D) shown in Figure 4, the classification of the soil in the profile investigated using classification charts (Figure 5), and the geotechnical parameters confined modulus and friction angle, estimated using the classic correlations proposed by Marchetti (1980) (Figure 6).

Figure 4 shows the high reproducibility of the DMT test results and low soil variability. Soil variability can be quantified by the coefficient of variation (COV). The COV of I_D, K_D, and E_D is 12.8%, 22.2%, and 18.2%, respectively. These values are much lower than those presented and discussed by Phoon & Kulhawy (1999) for DMT tests.

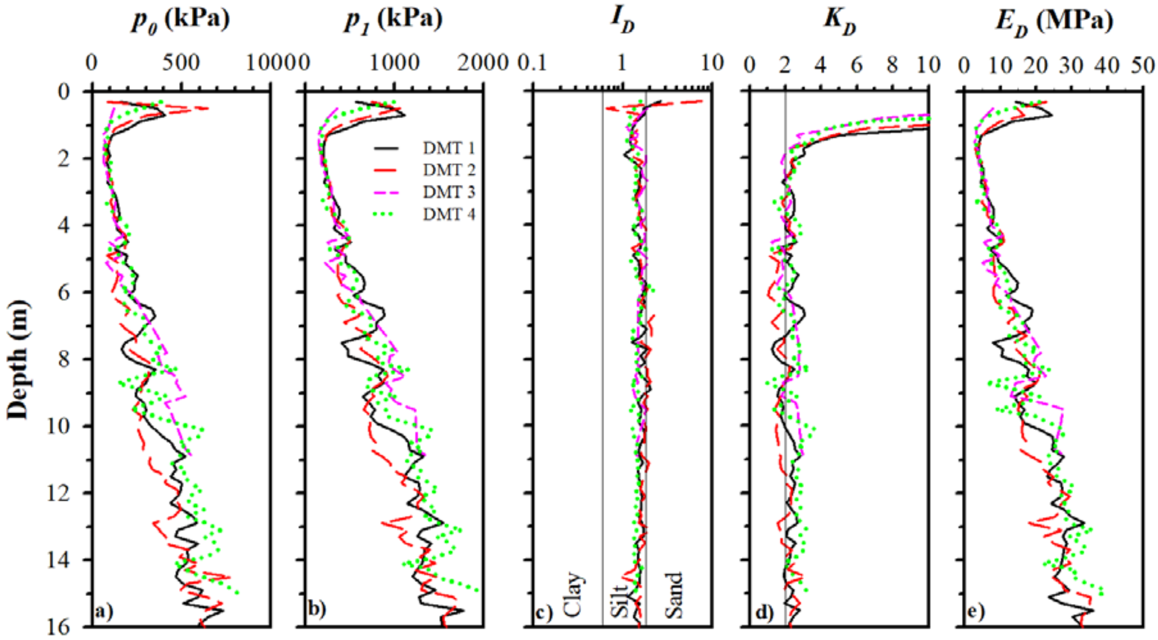


Figure 4 – DMT results.

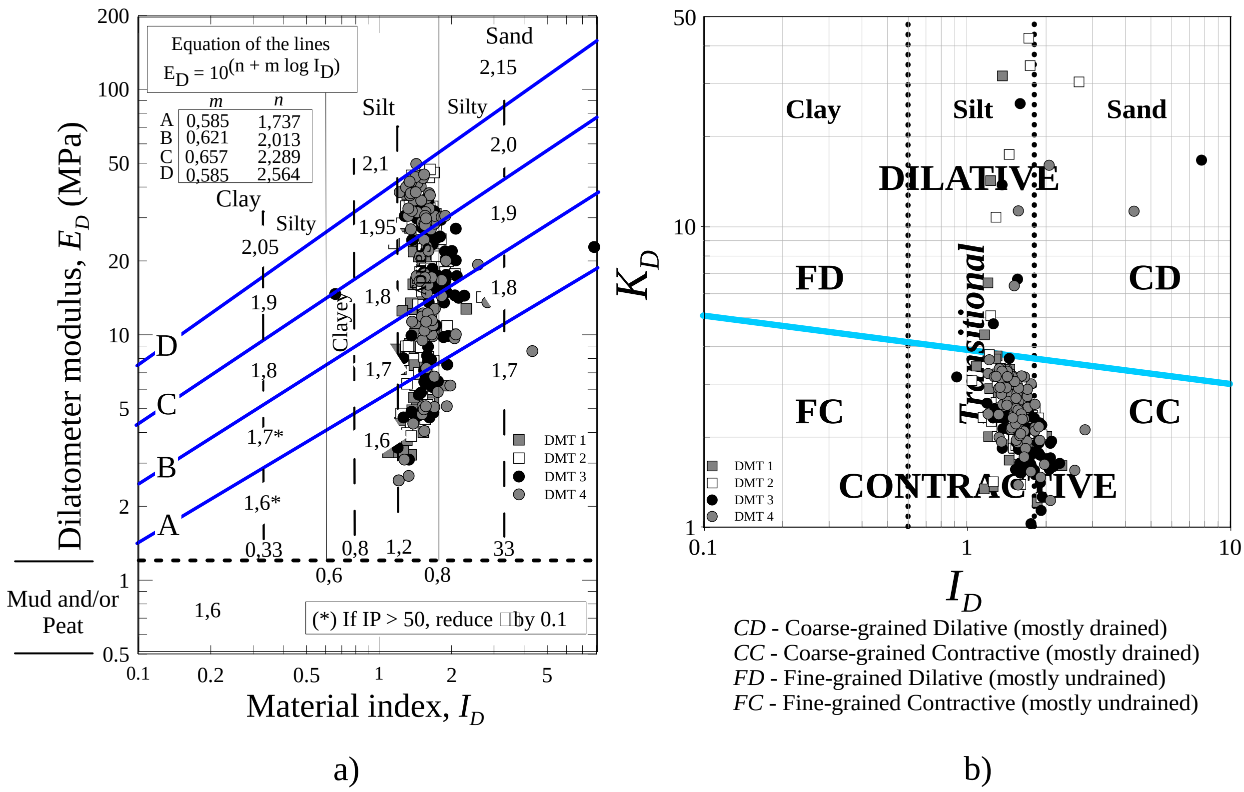


Figure 5 – Soil classification. a) Marchetti & Crapps (1981); b) Robertson (2015).

Plate Load Tests (PLTS)

The load bearing capacity calculation, as well as the estimate of immediate settlements in shallow foundations, can be obtained from plate load tests (PLTs). The PLTs were carried out following NBR 6489 (ABNT, 2019) and consisted of the installation of a 0.805 m diameter metal plate, and in a fast-loading condition, adopting a time of 15 minutes for each loading stage (Agnelli, 1997). The tests were carried out at depths of 1.0, 2.0, 3.0, and 4.0 m. The results of the plate tests carried out by Agnelli (1997) (Figure 7) were used to compare with the settlements estimated by the DMT test.

Terzaghi & Peck's (1967) recommendations were adopted as the criteria for defining the acting stresses to estimate the settlement by DMT test. These authors recommend that for common structures (commercial and residential buildings) in sandy soil, the total settlement for footings should not exceed 25 mm. Therefore, this value will be used as the total allowable settlement (r_a). Table 2 shows the stress values applied to the slabs for this admissible settlement value.

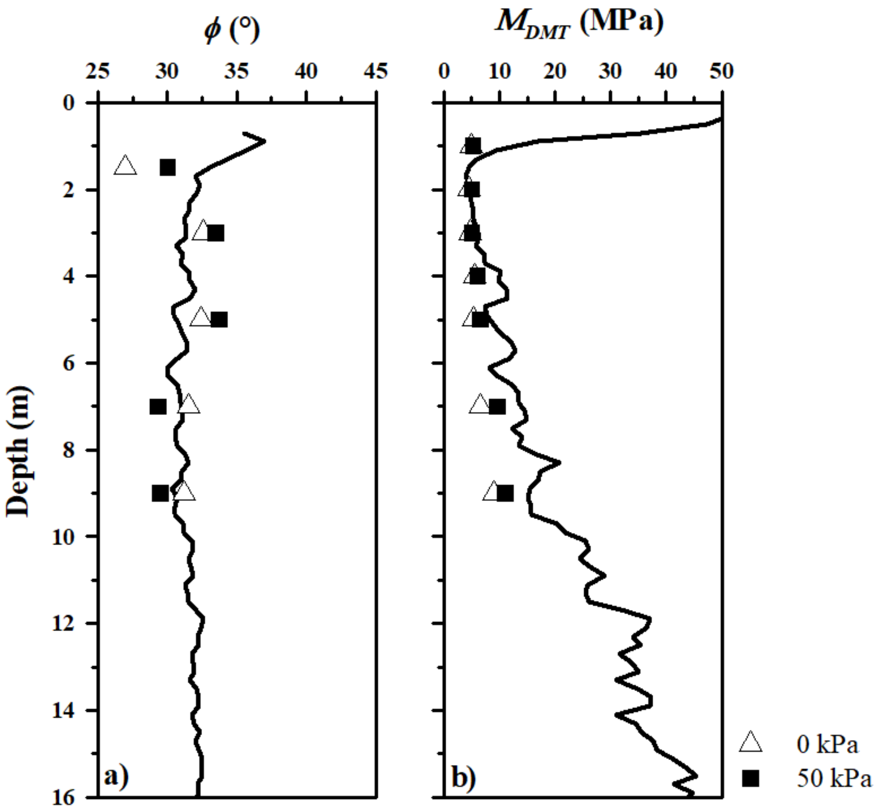


Figure 6 – Estimated parameters by DMT compared with laboratory test data.

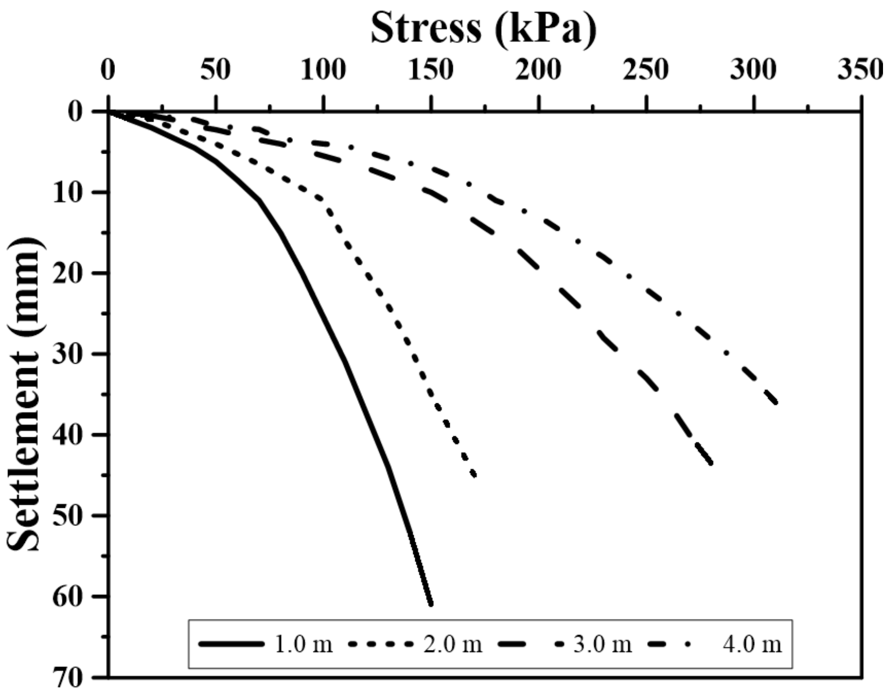


Figure 7 – Plate load tests (PLTs) previously performed at Unesp research site in natural soil condition (adapted from Agnelli, 1997).

Table 2 – Applied stress values for maximum allowable settlements.

Depth (m)	Applied stress (kPa)
1.0	105
2.0	132
3.0	228
4.0	282

DISCUSSION OF RESULTS

Soil classification

The soil classification was done using the chart proposed by Marchetti & Crapps (1981) (Figure 5a) and by the chart proposed by Robertson (2015). Figure 5 shows the classify-cation of the soil in the study site for the four tests. It is noticeable that the site profile was classified as sandy silt.

This classification is not very different from the grain size distribution determined without the use of a deflocculant (silty sand), which better represents what occurs in the study site. It should be noted that usually the material index indicates that a mixture of clay and sand would generally be described as silt, as pointed out by Marchetti et al. (2001). Only the topsoil (up to 1.0 m deep) was classified as silty sand.

The contractile/dilatant behavior of this soil was also assessed using the Robertson (2015) chart. Figure 5b shows the results of the four tests carried out. It can be seen in this figure that the entire profile was classified as silt (intermediate), with contractile behavior. Laboratory tests carried out by Fernandes et al. (2022) show that this soil exhibits contractile behavior at failure.

Geotechnical parameters

As the soil profile is in an unsaturated condition, the estimation of design parameters considered the effect of suction on the soil's mechanical behavior.

Thus, unsaturated triaxial and oedometer tests were carried out to support DMT interpretation. The suction value of 50 kPa was considered due to the monitoring of this variable over time at the study site.

Friction angle values (ϕ') determined by triaxial tests (Fernandes et al., 2022) in saturated and unsaturated conditions were used to compare with estimated values by the DMT (Figure 6a). Fernandes et al. (2022) studied the influence of the unsaturated condition (i.e., soil suction) on soil shear strength from undisturbed samples collected at 1.5, 3.0, 5.0, 7.0, and 9.0 m depth. These authors found that soil resistance increased with increasing suction.

The values of ϕ' varied from 27.0º for the sample collected 1.0 m deep in the saturated condition, to 31.2º for 50 kPa of suction, for the sample 9.0 m deep.

The cohesion intercepts increased from zero in the saturated condition for the sample collected at 1.0 m depth, to 22 kPa in the unsaturated condition (s = 50 kPa) for the sample collected at 9.0 m depth. Table 3 shows the friction angle (ϕ') and cohesion intercept values for the samples collected and tested in saturated and unsaturated conditions.

The values of ϕ' estimated by the four DMT agree reasonably well with the reference values (triaxial test) below 1.5 m depth. It was not the case for values above 1.5 m depth.

This may be due to the variation in water content and consequently in suction during the seasons, resulting in high p_0 and p_1 measurements, and consequently in the estimation of mechanical parameters by the DMT test.

This behavior was verified in CPT carried out in this research site over the course of one year by Giacheti et al. (2019). In addition, this behavior can be attributed to the fact that the estimated DMT ϕ' values incorporate the component of cohesion as a friction angle, since it assumes the soil behaves like sands.

Table 3 – Friction angle (ϕ') and cohesion intercept (c) values determined by triaxial tests (adapted from Fernandes et al., 2022)

Depth (m)	Friction angle (º)		Cohesion intercept (kPa)	
	Saturated	Unsaturated	Saturated	Unsaturated
1.5	27.0	30.0	0.0	3.0
3.0	32.6	33.5	1.2	6.5
5.0	32.4	33.7	5.3	9.8
7.0	31.5	29.3	3.9	26.0
9.0	31.2	29.5	4.5	22.0

One of the major applications of the DMT is to predict settlements by using Constrained Modulus (M_{DMT}). Figure 6b presents the estimated M_{DMT} values based on the data of four DMTs using Marchetti et al. (2001) correlation plotted together with the M_{OED} values determined based on oedometric tests by Saab (2016), for samples collected at 1.0, 3.0, 5.0, 7.0, and 9.0 m depth. The M_{OED} was equal to 4.8 at 1.0 m depth for the saturated condition and it increases with both depth and soil suction as shown in Table 4.

The average M_{DMT} is equal to 11.8 MPa between 1.0 to 6.0 m depth, 21.8 MPa between 6.0 to 13.0 m depth and 42.2 MPa below 13.0 m depth. Figure 6b shows that the M_{DMT} values estimated by DMT are in good agreement with those determined from oedometric tests, especially between 2.0 and 5.0 m depth, for both saturated and unsaturated conditions.

The observed differences for samples collected at 7.0 and 9.0 m depth may be related to the sampling process and preparation of the specimens, as well as due to the unsaturated condition, as observed for the friction angle.

Table 4 – Constrained modulus (M_{OED}) values determined by oedometer tests (adapted from Saab 2016).

Depth (m)	Constrained modulus (MPa)	
	Saturated	Unsaturated
1.0	4.8	5.2
2.0	4.5	5.0
3.0	4.7	5.0
4.0	5.5	6.0
5.0	5.3	6.6
7.0	6.5	9.5
9.0	9.0	11.0

Settlements prediction

Monaco et al. (2006) demonstrates that the DMT is a useful tool for settlement prediction. The authors showed that the mean ratio (R) between measured (MEAS) and estimated (DMT) settlements is approximately 1.3.

Figure 8 shows the differences between settlements predicted by the DMT and those measured by in situ load tests for the study site. Good agreement can be observed as most data points are within a satisfactory range, like that presented by Monaco et al. (2006) from over 40 representative points from various case histories.

Figure 9a and b shows the results of using the DMT settlement calculation program http://www.marchettidmt.it/software/index.htm to estimate the settlement for a 0.805 m diameter circular footing installed at 1.0 and 4.0 m depths.

This program enables the calculation of the vertical stress increase along the depth and the corresponding vertical deformation, as well as the total settlement of the footing.

Table 5 shows the predicted values of the DMT (ρ_{DMT}) and the ratio (R) between the measured and estimated settlements ($R = \rho_{MEAS}/\rho_{DMT}$) for the study site. The average ρ_{MEAS}/ρ_{DMT} ratio was 1.25, with values in the range of 1.02 to 1.60 with a standard deviation of 0.25. The settlement prediction by the DMT was satisfactory for all tests, as can be seen in Table 5 and Figure 8. This value is within the average value indicated by Monaco et al. (2006), where for more than 40 historical cases, they found an average value of R approximately equal to 1.3.

The main differences between the estimated and measured settlements occurred at 1.0 m depth, with soil suction influence on p_0 and p_1 measurements from DMT, and consequently on the intermediate parameters (I_D, K_D, and E_D) probably being the reason for that. Interpretation of CPT performed over one year in this site by Giacheti et al. (2019) shows the great influence of soil suction on tip resistance (q_c) and sleeve friction stress (f_s) up to 4.0 m depth.

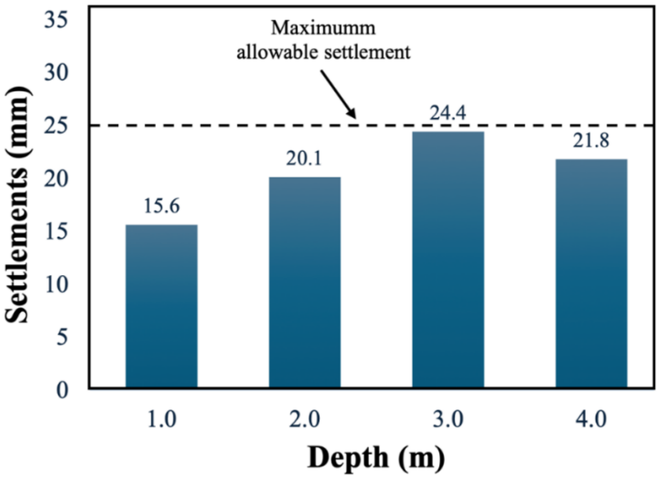
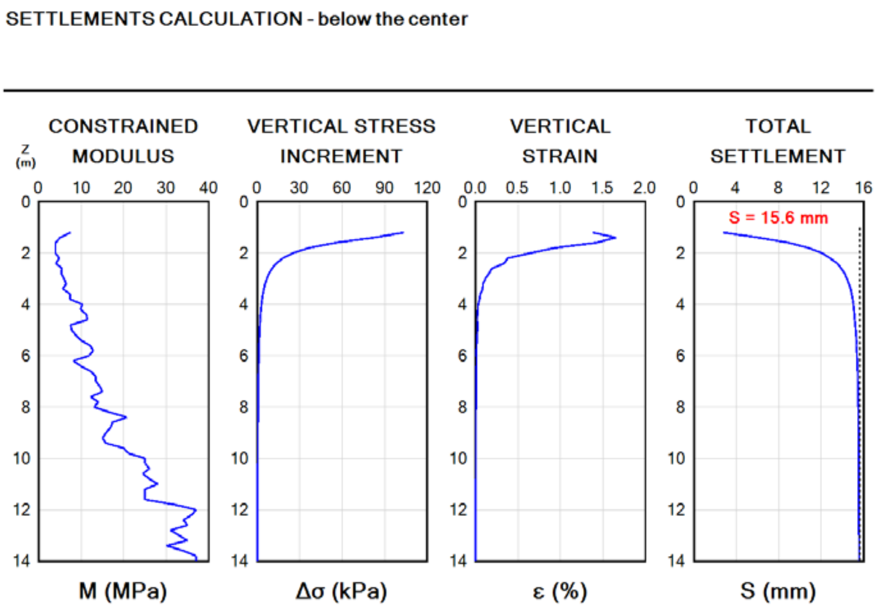
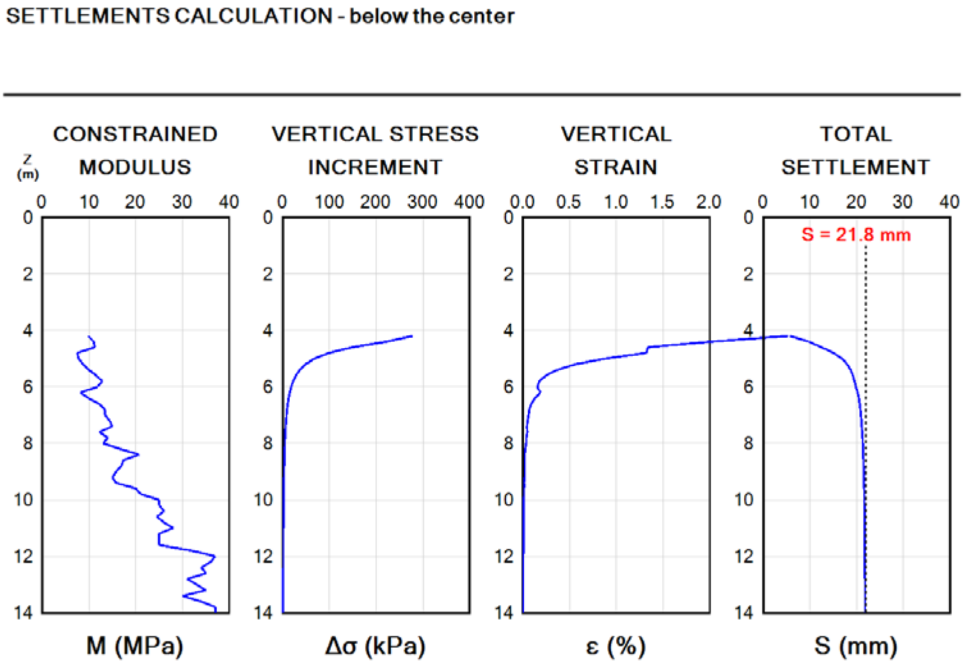


Figure 8 - Settlements predicted by DMT *vs* those measured by the in situ load tests for the study site.



a)



b)

Figure 9 - Typical results of the settlement calculation software. a) 1.0 m depth; b) 4.0 m depth

Rocha et al. (2021b) also observed the soil suction effects on p_0 and p_1 for a tropical sandy soil like that occurs in the study site. These authors concluded that it is necessary to consider the effect of suction and its variation throughout the year for proper interpretation of in situ test data.

Table 5 – Estimated and measured settlements as well as ρ_{esti}/ρ_{DMT} ratios for the study site.

Depth (m)	ρ_{DMT} **(mm)**	ρ_{MEAS}/ρ_{DMT} **(mm)**
1.0	15.6	1.60
2.0	20.1	1.24
3.0	24.4	1.02
4.0	21.8	1.14

The *OCR* also has an influence on the determination of settlement, as it causes a significant increase in the stiffness of sandy soils (Clayton et al., 1985; Marchetti & Monaco, 2018). Marchetti (1980) points out that K_D profiles are similar in shape to *OCR* profiles, where normally consolidated soils tend to have a K_D of around 2 and over consolidated soils values higher than 2. Normally consolidated soils affected by cementation and suction also have K_D values greater than 2

(Marchetti et al., 2001; Marchetti & Monaco, 2018).

Figure 4d shows that the K_D values up to a depth of 2.0 m are greater than 2, which is another indication of the soil suction influence or a possible soil microstructure (cementation and/or bonding) which would affect the p_0 and p_1 measurements and consequently the M_{DMT} calculation (Rocha et al., 2021a).

CONCLUSIONS

This paper presented and discussed four DMTs carried out on a clayey fine sand profile located on the Unesp Experimental Research Site in Bauru. The soil profile was classified, and design parameters were estimated by classical correlations, which were compared with reference values.

The settlement was also estimated using the traditional elastic-linear approach and these results were compared with plate load tests (PLTs) previously carried out at this site at 1.0, 2.0, 3.0 and 4.0 m depths. It is possible to draw the following conclusions:

- The friction angle profile (ϕ') for this site showed good agreement with the reference values. The values of ϕ' above a depth of 1.5 m were found to be higher than those determined by triaxial tests in saturated and unsaturated conditions. The influence of suction on the DMT measurements could explain it, as well as the fact that correlations to estimate the shear strength of sandy soils are based only on ϕ'. Thus, the values of ϕ' above a depth of 1.5 m must be considered, in addition to friction, the cohesive portion arising from suction and possible cementation present in this tropical soil.
- The M_{DMT} profile determined by DMT agrees with the values determined by oedometer tests in saturated and unsaturated conditions, except for the sample collected at a depth of 1.0 m. This behavior may have affected the prediction of settlement at this depth by the DMT, as can be seen in Table 5.
- The settlements predicted by DMT are in good agreement with observed settlement for all the plate load tests (PLTs), except for PLT performed at 1.0 m depth (Table 5). This behavior can be associated with the influence of soil suction, which affects p_0 and p_1 and, consequently, M_{DMT}.

It indicates the need to consider the effect of suction when interpreting in situ tests, as the mechanical behavior of unsaturated tropical soils is strongly influenced by it.

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