16th World Conference on Earthquake Engineering, 16WCEE 2017
Santiago Chile, January 9th to 13th 2017
Paper N° 339
Registration Code: S-W1464707674

CORRELATIONS BETWEEN THE MENARD PRESSUREMETER TEST AND CPT FOR SOME ALGERIAN SOILS

N. Mezouar[(1)], R. Bencharif[(2)] and S. Bedr[(2)]

[(1)] *Associate Professor, Centre National de Recherche Appliquée en Génie Parasismique Algiers, Algeria, nmezouar@cgs-dz.org*
[(2)] *Researcher, Centre National de Recherche Appliquée en Génie Parasismique Algiers, Algeria*
…

Abstract

This paper presents a statistical analysis of Menard pressuremeter parameters (Em, pllim) and cone penetration test (CPT) correlations for soils in Algeria. The data are obtained from geotechnical investigations carried out in several sites, in northern Algeria, intended for electrical power plants projects. The stratigraphy of these sites reveals a layer of saturated sands relatively loose overlying marl. Additional data from similar sites were used.

After presentation of synthesis of existing correlations, the results of the study are detailed and compared with the existing ones. Comparison between the present results and the few correlation suggested in literature indicates that the already existing equations may not be suitable for soils in Algeria.

The results obtained in term of correlation allow will us to move from pressuremeter parameters, widely obtained in Algeria, to the cone penetration resistance (CPT) with a good approximation. It will be used to help the quality control of in situ geotechnical results and increase the reliability of geotechnical parameters to be used in site classification and foundation calculation

Keywords: Menard pressuremeter test, CPT, correlation

1. Introduction

The soil is naturally an heterogeneous material, deposited by several natural actions. The result is varying in types and stratigraphy. Therefore, it is a not an easy task for geotechnical engineers to simplify a soil profile that can be developed and used in site classification or foundation design. In situ soil tests, obtained by several equipment, give relatively reliable results that can help engineers in their decisions. A variety of in situ test machines exists, providing very different parameters. These were correlated in order to normalize the meaning and be able to classify independently the sites.

In Algerian seismic code (RPA99/2003), the site classification is established from properly substantiated geotechnical data of the supporting ground. This classification is done through four soil profile types, designated as S1 through S4, based on the average soil shear wave velocity for the upper 20-30m of the soil profile. When this latter is not available, standard penetration blow count (NSPT), undrained shear strength (cu), cone penetration tip resistance (qc) or Menard pressuremeter data (Em and Plim) may be used as an alternative.

The reliability of using the pressuremeter parameters requires a comparison or correlation with the test results widely used in the classification of sites (VS, qc and NSPT).

Several researchers have proposed relationships between the most common used in situ parameters: the SPT, CPT and shear wave velocity (Vs). Correlations of pressure meter parameters with these settings are very limited in the literature. In general, these correlations are given depending on soil type. Cassan, 1978 proposed a ratio between Menard pressuremeter modulus (Em) and cone penetration tip resistance (qc) of 2.5 up to 3.3 for clays and a lower ratio for silts (2.3-3.0) and concluded that the ratio remains substantially equal to 1 for sand. For normally consolidated clays, Shahrour, 2005 gave a ratio of 4.5 and demonstrated that this ratio can reach 7 in case of over consolidated clays. Bahar et al., 1999 suggested, from a series of in situ tests carried out in the Algerian clays, values of Em/qc between 3.0 and 4.9. In all cases, in the limited existing references, the values of Em/qc ratio are bounded between 2.5 and 7 for clays, 1 and 4.5 for silt and 0.5-1.5 for sands. These correlations serve as conversion tool of the available database of either one of the two in situ tests into the other test's parameter.

In Algerian seismic code (RPA99/2003), the site classification is established from properly substantiated geotechnical data of the supporting ground. The classification ranging from site type S1 to S4 is described by the profiles and average parameters given hereafter.

Type	**Definition**	$\overline{q_c}$ **(MPa)**	$\overline{N}$	$\overline{Pl}$ **(MPa)**	$\overline{Em}$ **(MPa)**	$\overline{c_u}$ **(KPa)**	$\overline{Vs}$ **(m/s)**
S1	A rock or other soil characterized by a shear wave velocity greater than 800m/s or by other suitable means of classification (other columns)	/	/	**>5**	**>100**	>10	>800
S2	A soil profile of very dense sand or gravel and/or over consolidate clays on 10 to 20m depth characterized by a shear wave velocity greater than 400m/s after 10m depth or by other suitable means of classification	>15	>50	**>2**	**>20**	>0.4	>400
S3	A soil profile of predominantly medium-dense sand or gravel and/or medium-stiff clays characterized by a shear wave velocity greater than 200m/s after 10m depth or by other suitable means of classification	>1.5	>10	**>1**	**>5**	>0.1	>200

S4	A soil profile containing loose sand with presence or not of soft clay characterized by a shear wave velocity less than 200m/s in the first 20m or by other suitable means of classification. A soil profile containing soft to medium stiff clay characterized by a shear wave velocity less than 200m/s in the first 20m or by other suitable means of classification.	<1.5	<10	**<1**	**<5**	<0.1	<200

Vs is the average wave velocity of the top layers that may be determined in accordance with the thickness and shear wave velocity of various soil layers. When Vs is not available, cone penetration tip resistance (qc) or Menard pressuremeter parameters (pl and Em) may be used as an alternative. The reliability of using the pressuremeter parameters requires a correlation with the test results widely used in the classification of sites (Vs, qc,...).

This paper presents a statistical analysis of Menard pressuremeter parameters (Em, pllim) and cone penetration test (CPT) correlations for soils in Algeria. The data are obtained from geotechnical investigations carried out in several sites, in northern Algeria, intended for electrical power plants projects. The stratigraphy of these sites reveals a layer of saturated sands relatively loose overlying marl.

2. Geotechnical data

In situ investigation carried out in three sites in north Algeria (LCTP, 2013; LCTP, 2015; LNHC, 2013, LCTPE, 2008), usually situated along the Mediterranean sea, intended for electrical power plants are used in present study. An average of 24 boreholes were drilled in each site.

Within the sites of interest, the stratigraphy consists of loose to dense sand layer with alternating sometimes of sandstone, with a depth varying from 9m to 30m overlying Plaisancian Marl layer with a significant thickness. In addition to laboratory tests, the following measurements were also made:

- Pressuremeter tests (27)
- CPT (53)

The results of investigation in the Mostaganem and Algiers sites (West and centre of Algeria respectively) are shown as example in the following figures. The obtained results in term of pressuremeter parameters (Pl and Em) are shown in figure 1 for Mostaganem site and in figure 2 for Algiers site

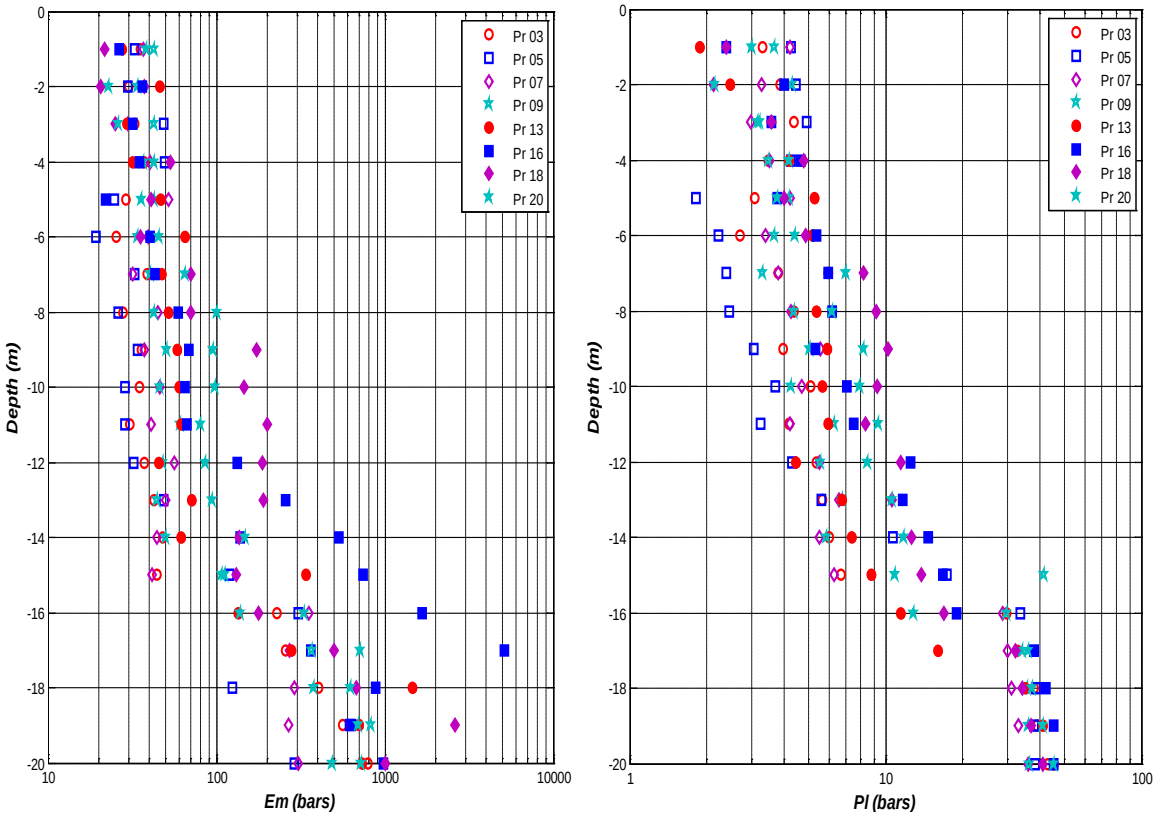

Fig. 1: Profile of Pressuremeter parameters at Mostaganem site

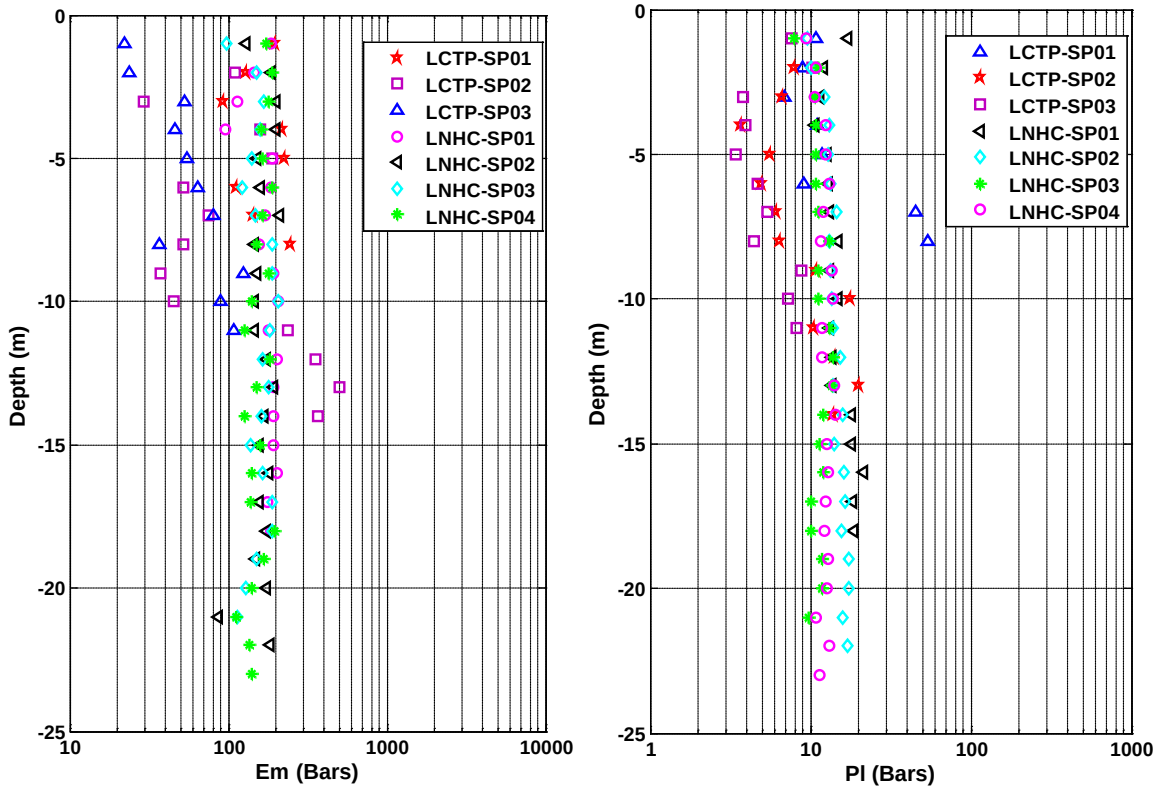

Fig. 2: Profile of Pressuremeter parameters at Algiers site

The CPT results are shown in figures 3 in term of cone tip resistance. They exhibit a relative constant variation in the fifteen first meters (10m of sand and 5m of sandy marl) and decrease in the weathered marl layer in Mostaganem site. This trend is not repeated in the case of pressuremeter parameters shown in figure 1 where the parameters (Em, Pl) tend to increase in sandy marl and weathered marl. In case of Algiers site, the cone tip resistance increases with depth because this site is essentially sandy clays and conglomerates.

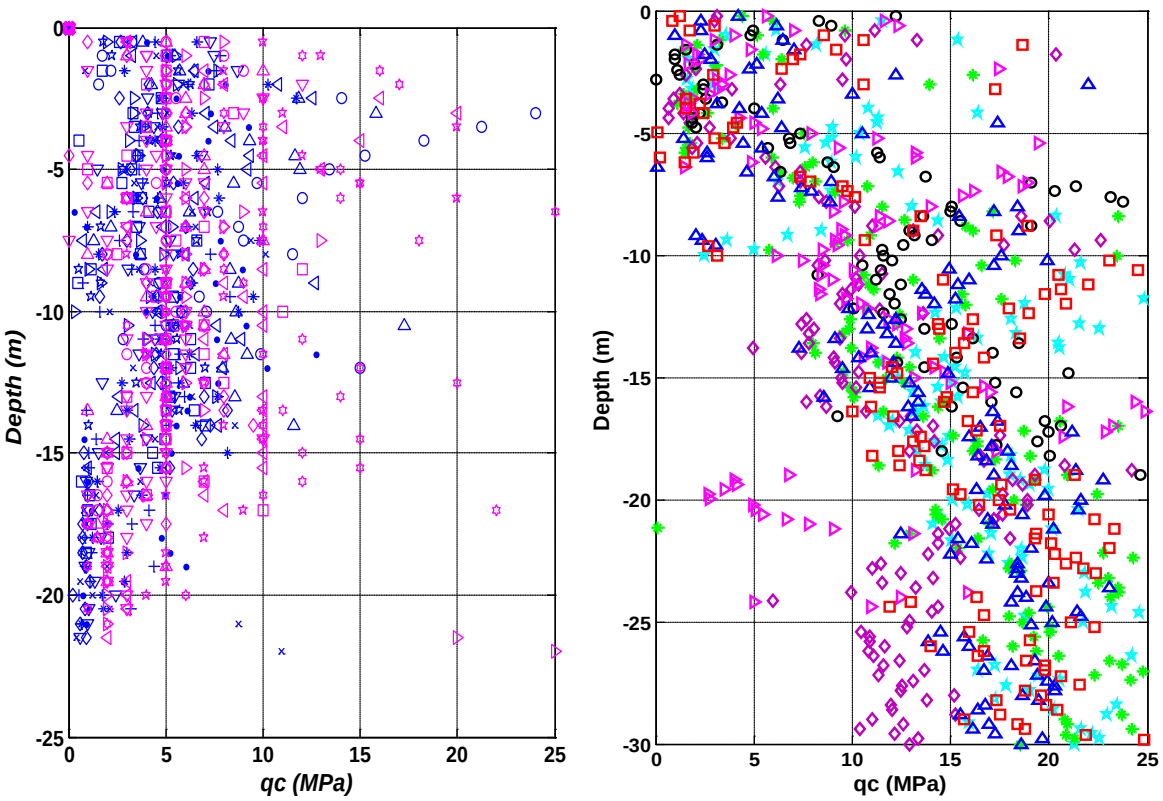

Figure 3: Profile of Cone tip resistance at Mostaganem site (left) and Algiers site (wright)

3. ANALYSIS OF DATA

To objective is to find the best equation representing correlation between pressuremeter parameters (Em and Pl) and the cone resistance tip for the data reported in different figures related to sandy soils (sand, sandy marls, sandstones and conglomerates). The principle is to associate to each value obtained by pressuremeter test (Em and pl) a value obtained by a other test representative the same soil type and depth. The mean objective in this study is to give a range of values for different tests which are correlated and can be used to establish the site classification and results testing. For easy searching, the ratios between parameters are looked. Statistical tools give us different values of these relations and the minimum and maximum of the mean and the slope of the linear regression taken into consideration. This choice will give relatively larger range but safer than a single value.

Figure 4 show the ratios between parameters (qc/Pl and qc/Em). This ratio vary from 7 to 8 for the first ratio and from 0.6 to 0.7 for the second ratio. It is important to mention that the ratio Em/qc take lower values for loose sand, as our case, compared to the ones in literature.

Figure 5 show the relation between pressuremeter parameters and cone penetration resistance and the fitting data. The obtained fitted relation for pressuremeter limit (pl) and cone penetration resistance (qc) for loose sand is of the form: $pl = 0.08 * qc + 0.15$ and for pressuremeter modulus and cone penetration resistance the relation is $Em = 0.37 * qc + 6.5$

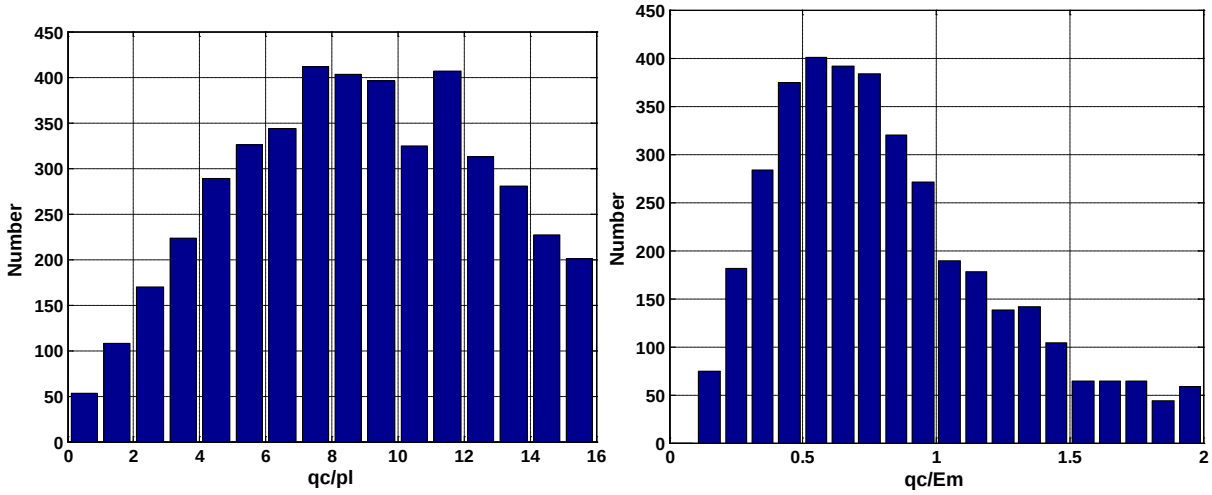

Figure 4. Distribution of qc/pl and Em/pl for sand

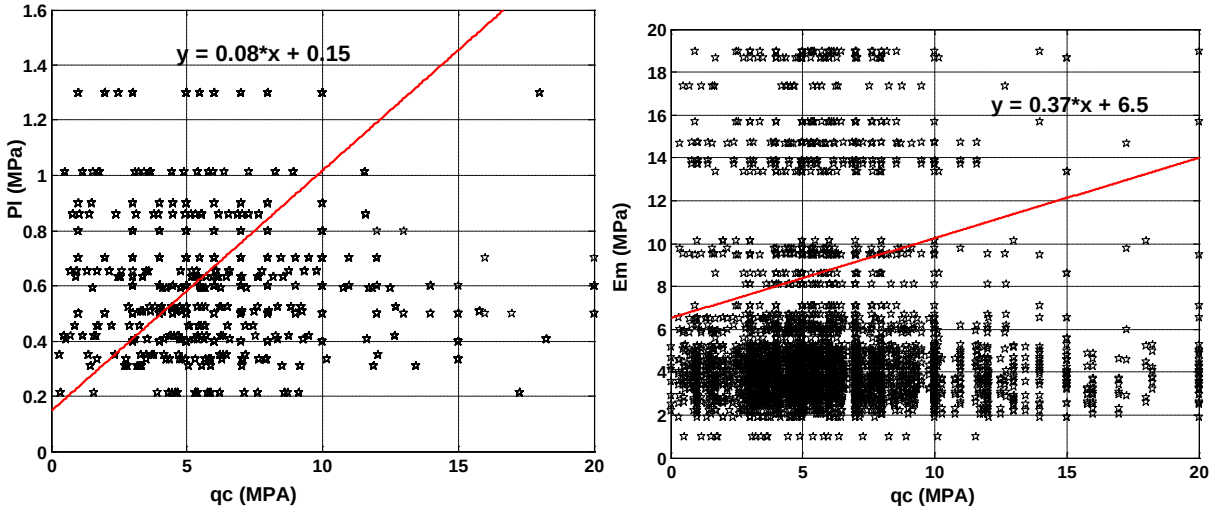

Figure 5. Relation between pressuremeter parameters and cone penetration resistance of sand and fitted relations

3. Conclusion

This modest research, which is just beginning, has shown the relation of pressuremeter parameters with cone resistance tip for loose sandy soil. These relations, direct, are very practical, can be used in the future.

The work will continue for other kind of sands and the marl. A lot of sites near the sea present a stratigraphy of marl underlying saturated sands; This induces an intermediate layer of 5-10m of weathered marl for which it is important to affect parameters. For the studied sand, it has shown that:

The ratio qc/Em is in the range 0.6-0.7. This range is relatively lower compared to the one in literature, because of the sand studied which is loose. The ratio qc/pl varies from 7 to 8.

4. References

[1] Bahar R., Kaoua F., Aissaoui T. (1999) Quelques corrélations entre essais in situ et essais de laboratoire pour certaines argiles algériennes, in Geotechnics for developing Africa, edited byr Wardle G.R., Blight G.E., Fourie A.B., Balkema, Rotterdam, ISBN 90-5809-082-5, 255–262.

[2] Cassan M. (1978) “Les essais in situ en mécanique des sols Réalisation et interprétation”, Eyrolles, Paris.

[3] Kulhawy, F. H., and P. W. Mayne. Manual on Estimating Soil Properties for Foundation Design. Palo Alto, California: Electric Power Research Institute, 1990.

[4] LCTP Laboratoire Central des Travaux Publics, (2013), Rapport géotechnique et géophysique du site de Mostaganem.

[5] LCTP Laboratoire Central des Travaux Publics, (2015), Rapport complémentaire géotechnique et géophysique du site de Mostaganem.

[6] LNHC Laboratoire National de l'Habitat et de la Construction, (2013), Rapport géotechnique et géophysique du site d'El Mohammadia.

[7] Lee, S.H.H. 1992. Analysis of the multi co linearity of regression equations of shear wave velocities. Soils and foundations; Japanese society of soil mechanics & foundation engineering. 32(1): 205-214.

[8] Meigh, A.C., and I.K. Nixon. "Comparison of in-situ tests of granular soils." Proceedings of 5th international Conference on Soil Mechanics and Foundation Engineering. Paris, 1961

[9] Robertson, P. K., and R. G. Campanella. "Interpretation of Cone Penetration Tests: Part I: Sand." Canadian Geotechnical Journal, Vol. 20, No. 4, 1983: 718-733.

[10] RPA99/2003, (2003) Algerian seismic code, Centre National de Recherche Appliquée en Génie Parasismique (CGS)

[11] Shahrour I. and Gourvès R. (2005), “Reconnaissance des terrains in situ”, Hermès – Lavoisier, ISBN 2-7462-1135-1.