International Journal of Science and Healthcare Research
Vol. 9; Issue: 4; October-December 2024
Website: ijshr.com
Research Paper *ISSN: 2455-7587*

Study of the Correlation between Pressuremeter Limit Pressure and Dynamic Resistance obtained by the Dynamic Probing Super Heavy (DPSH) of the Sands of Lome in Togo

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DOI: https://doi.org/10.52403/ijshr.20240420

ABSTRACT

The design of building foundations relies on a good understanding of the bearing capacity of soils, which is determined by various in situ testing methods, such as pressuremeter and penetrometer tests. The pressuremeter test provides valuable information on the strength and deformability of soils at depth, while the dynamic cone penetrometer more easily assesses the dynamic resistance of the soil under dynamic loads.
In this study, correlations were established between the dynamic resistance qd measured with the dynamic probing super heavy and the limit pressure pL obtained with the Menard pressuremeter. The data collected come from geotechnical investigations carried out on sandy soils of Lome in Togo. For these soils, the ratio is in the following interval: $8.27 \leq qd/pL \leq 9.74$.

Keywords: correlation, dynamic resistance, limit pressure, sand.

INTRODUCTION

In Togo, the assessment of the bearing capacity of soils for the design of foundations is based on in situ tests, in particular pressuremeter and penetrometer tests, in accordance with the recommendations of DTU 13.1 [1] and 13.2 [2], as well as Fascicle 62 – Title V [3]. The pressuremeter test makes it possible to analyse the resistance and deformability of soils in depth, while the dynamic penetrometer, due to its simplicity, is widely used to multiply the investigation points on a construction site. However, the dynamic penetrometer test has a limitation, because it only measures the dynamic resistance of the soil, which limits the wealth of information collected compared to the Menard pressuremeter test. The latter makes it possible to determine more diverse parameters, such as the pressuremeter modulus and the limit pressure [4]. This distinction reduces the ability to fully characterize the mechanical properties of soils based solely on the results of the dynamic penetrometer.
Although some soil properties can be related by mathematical formulas, there is no direct relationship between the pressuremeter limit pressure and the dynamic resistance obtained by the penetrometer [5]. However, by seeking to establish correlations between these two parameters, it is possible to improve the interpretation of the data from the dynamic penetrometer and to access more complete and relevant geotechnical parameters [6]. This method is particularly beneficial for the design of foundations, because it facilitates the extrapolation of pressuremeter parameters from the results of

the dynamic penetrometer. This makes it possible to increase the accuracy of the calculations while reducing the need for pressuremeter tests, which are generally more expensive.
This study explores qd/pL ratios based on combined tests carried out on sandy soils of Lome, and compares them to existing geotechnical literature.

MATERIALS & METHODS

The surveys were carried out on 4 sites distributed in the communes of Golfe 1 and Golfe 6 of the Autonomous District of Greater Lome (DAGL): Ablogame, Adakpame, Baguida and Lome Port. The locations of these sites are shown in Figure 1. Geologically, these sites are part of the coastal sedimentary basin made up of marine sands of the coastal strips. The formation of these coastal strips took place during periods of sea level oscillation. With a maximum thickness of 25 m, they occupy the entire maritime facade of the country, from Lome where they reach 2 km wide, to Aneho where they measure less than 1 km [7].

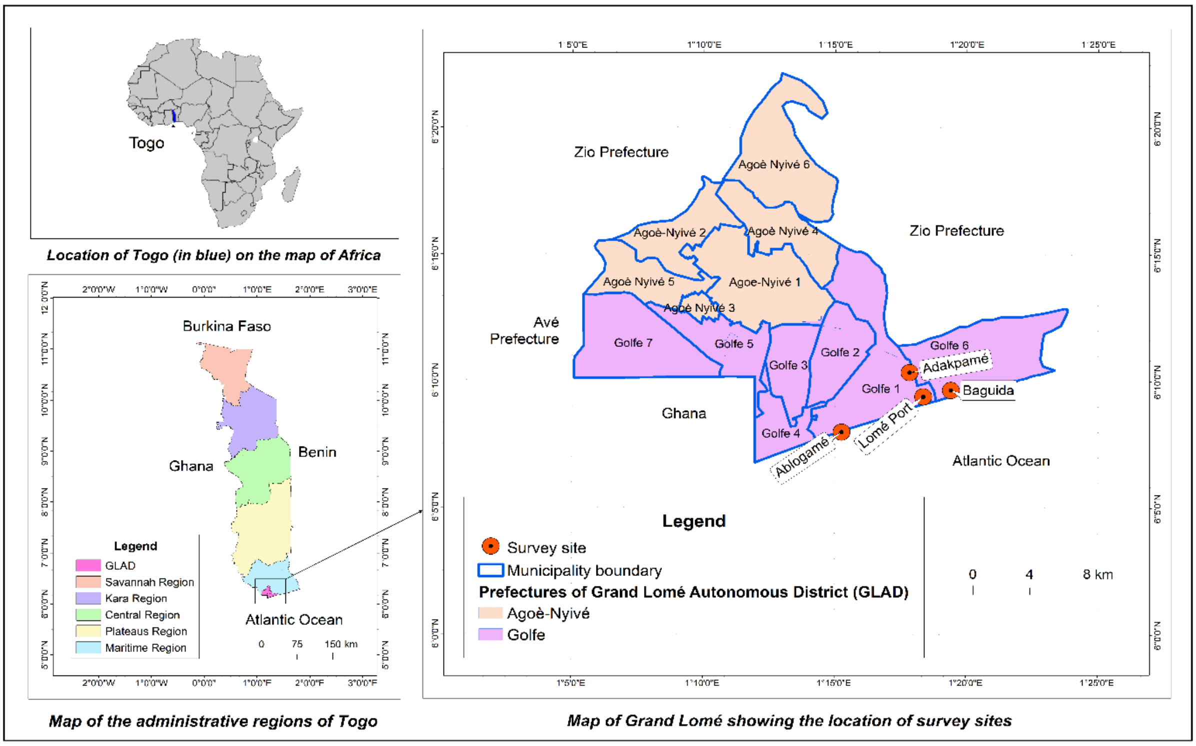

Figure 1: Location of survey sites

The approach adopted aims to establish a relationship between the dynamic resistances qd obtained by the Dynamic Probing Super Heavy (DPSH) and the limit pressures pL measured during the pressuremeter tests on the 4 sites studied.
Before that, the main parameters defining the nature of the soils on these sites, such as the granulometry, the methylene blue value (VBS), the particle density and the classification according to GTR (Guide des Terrassements Routiers) [8], were established to better contextualize the results.

The pressuremeter tests were carried out in accordance with standard NF P 94-110 [9], and the DPSH followed standard NF EN ISO 22476-2 [10].
For each depth p of measurement during the pressuremeter test, an average penetration resistance value is calculated over a depth interval centered around this depth (from p – 50 cm and p + 50 cm). This method makes it possible to associate with each limit pressure pL obtained a corresponding average penetration resistance qd. A statistical analysis of the ratios between these two values qd pL is then carried out.

Table 2 presents the total number of surveys carried out during the mixed campaigns on the 4 sites studied, as well as the number of combinations of qd/pL ratios obtained. It should be noted that each pressuremeter survey at a point corresponds to several DPSH surveys carried out in the vicinity of this point on the same site.

Table 1: Quantity of materials used

Designation	Quantity
Penetrometer survey	16
Pressuremeter survey	8
pL ratio	151

This study aims to define ranges of values for the qd/pL ratios that characterize sands. Using statistical analysis of the data, intervals were determined by taking into account the extreme values (minimum and maximum) of the following four statistical indicators: the mean, the median, the mode of the distribution and the slope of the linear regression. This approach allows to take into account the variability of the data as well as the uncertainties associated with in situ tests.

RESULT AND DISCUSSION

The main geotechnical parameters defining the nature of the soils of the sites analysed are illustrated in Table 2 and Figure 2.

Table 1: Parameters of the nature of the soils studied

Site	D < 80 µm (1) (%)	D < 2 mm (1) (%)	D_{max} (2) (mm)	VBS (3)	Particle density γ_S (g/cm³)	GTR Class (4)
Ablogame	2.3	95.3	2	0.05	2.53	D1
Adakpame	6.5	95.1	2	0.07	2.59	D1
Baguida	11.2	93.8	3.15	0.08	2.56	D1
Lome Port	1.5	87.7	4	0.03	2.60	D1

(1) "D<x" = percentage of passages through the sieve with mesh size x
(2) Maximum diameter of soil particles (diameter for which 95% of the particles are of a smaller dimension)
(3) VBS : Methylene Blue Value
(4) GTR : Guide des Terrassements Routiers [8]

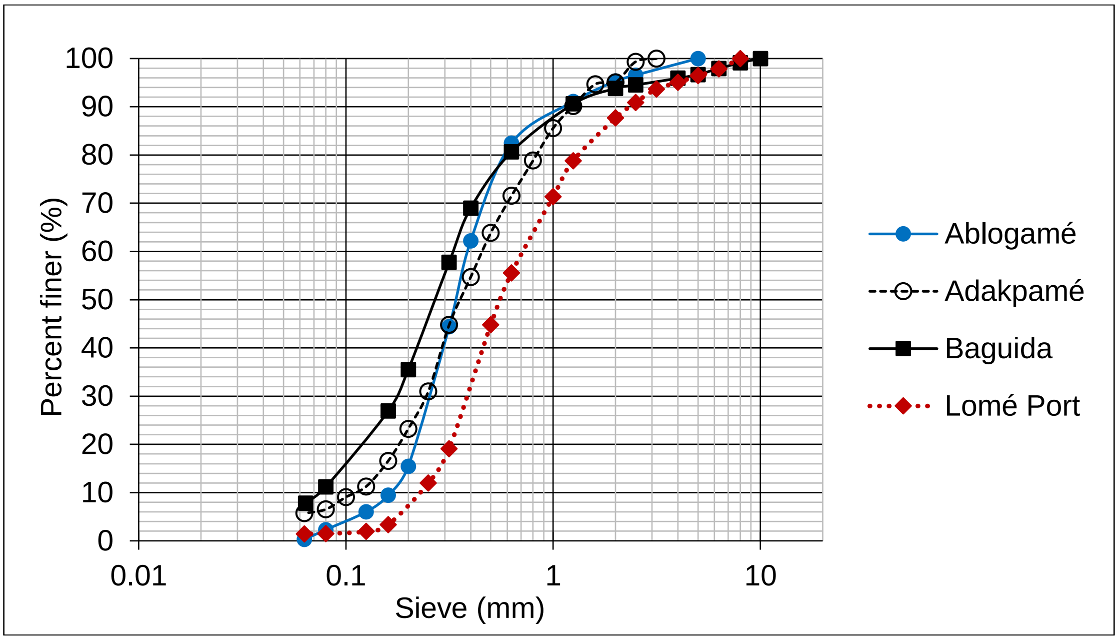

Figure 2: Granulometric curve of the soils studied

The mean and median of the qd/pL ratios are 9.06 and 8.79, respectively. The linear relationship suggested by the scatter plot in Figure 3 gives a slope qd/pL = 9.74.

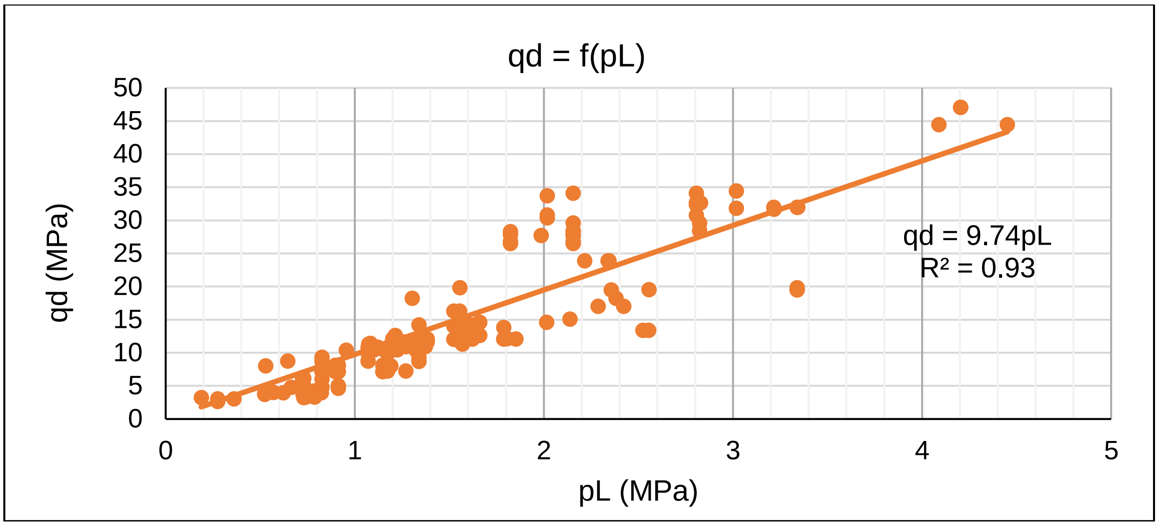

Figure 3: Variation of qd as a function of pL

By grouping the qd/pL values on the one hand, and the log (qd/pL) values within classes represented by the histograms in Figure 4, a log-normal probability law was calibrated for this distribution. The maximum frequency, i.e. the mode, is given for qd/pL = 8.27.

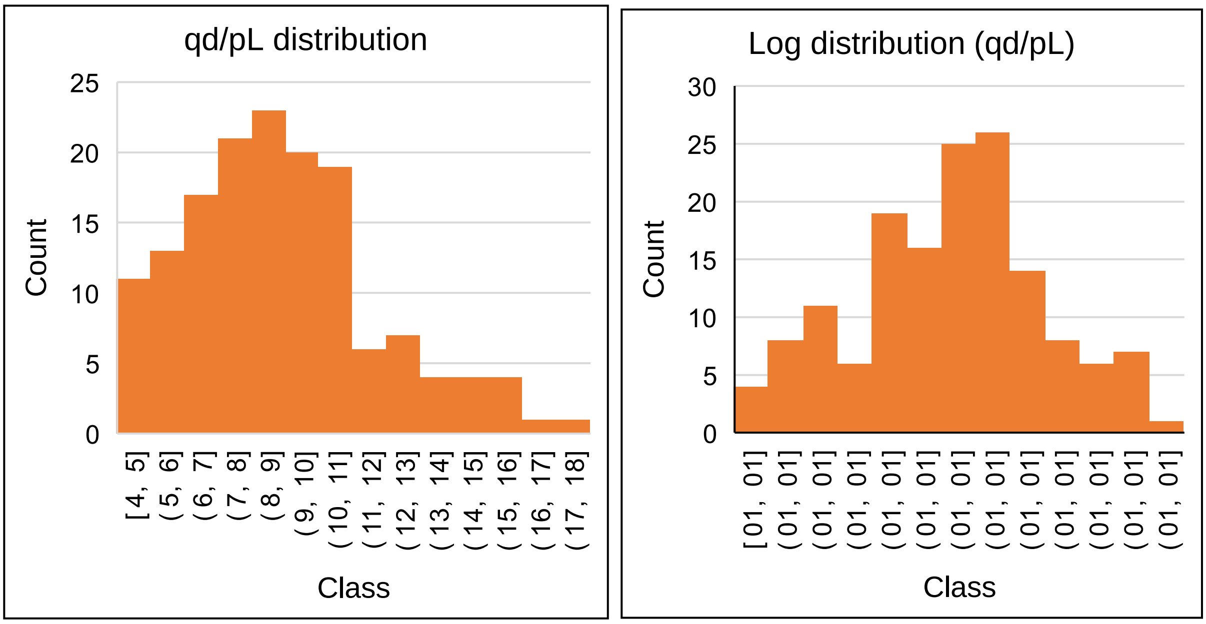

Figure 4: Distribution histograms of qd/pL and log(qd/pL)

The statistical indicators resulting from the distribution of qd/pL ratios are summarized in Table 3.

Table 3: Statistical indicators of the qd/pL distribution

Indicator	Value
Mean qd/pL	9.06
Median qd/pL	8.79
qd/pL linear regression slope	9.74
Mode of the log normal distribution qd/pL	8.27
Minimum indicator	8.27
Maximum indicator	9.74

From the data in Table 3, the interval $8.27 \leq qd/pL \leq 9.74$ is proposed for the sands of Lome.

Previous research focuses mainly on the comparison between pressuremeter tests and static cone penetrometer tests (CPT). In the absence of comparative research on dynamic cone penetrometer (DCP), data from past studies on static cone penetration tests will provide insights into the relevant geotechnical parameters. This information will be used to establish analogies and hypotheses for the present study, while taking into account the fundamental differences between the two test methods.

As for sands, a synthesis of the values found in the literature for the qC/pL ratios (where qC represents the resistance obtained with the static cone penetrometer) allows the results to be grouped in Table 4.

Table 2: Summary of qC / pL ratios

Authors	**qC/pL**
Vaillant & Aubrion [11]	$8.10 \leq qC/pL \leq 9.10$
Costet & Sanglerat [12]	$7.00 \leq qC/pL \leq 9.00$
Van Wambeke & D' Hemricourt [13]	$5.00 \leq qC/pL \leq 12.00$
Schmertmann [14]	$1.00 \leq qC/pL \leq 1.50$
Cassan [15]	$8.00 \leq qC/pL \leq 10.00$
Baguelin et al. [16]	$5.00 \leq qC/pL \leq 12.00$
Ménard [17] & Van Wambeke [18]	$7.00 \leq qC/pL \leq 10.00$

In Figure 5, the results of this study are compared with those of the bibliographic synthesis, which confirms the general consistency of the results obtained ($8.27 \leq qd/pL \leq 9.74$) with the data provided by the various authors.

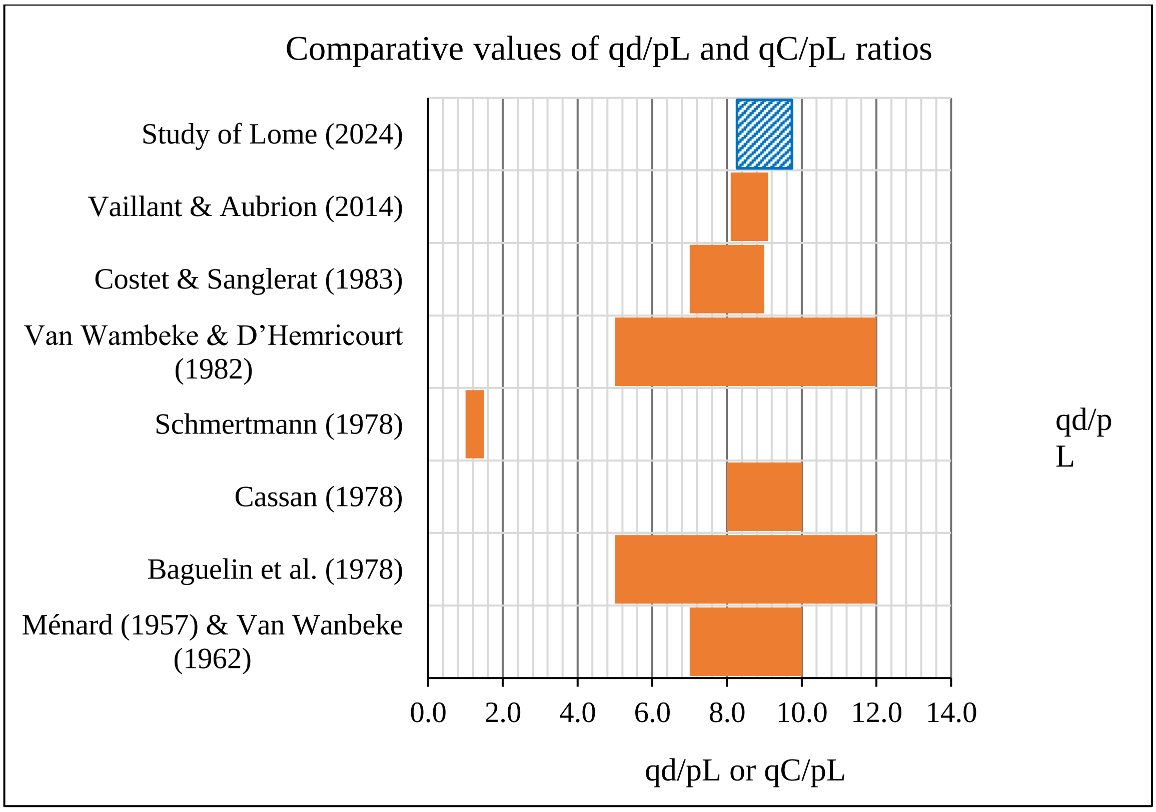

Figure 5: Comparative values of the qd/pL ratios of Lome to the qC/pL ratios of the literature for sands

CONCLUSION

This study highlights the relationship between the dynamic cone resistance qd and the limit pressure pL for the sands of Lome, providing an interval of $8.27 \leq qd/pL \leq 9.74$. These results are consistent with existing literature and provide references for the design of foundations on these soil types. Further studies could explore other soil types and strengthen local geotechnical bases.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Sabankou KPATADOA, Abalo P'KLA, Ezouwè KESSIE. Study of the correlation between pressuremeter limit pressure and dynamic resistance obtained by the dynamic probing super heavy (DPSH) of the sands of Lome in Togo. *International Journal of Science & Healthcare Research.* 2024; 9(4): 147-152. DOI: *https://doi.org/10.52403/ijshr.20240420*

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