JOURNAL OF ENGINEERING RESEARCH

V. 1 MARCH 1989

The Journal of Engineering Research is Published by The Engineering Research Center Tripoli, Jamahirya

CONTENTS

الربط بين معامل الاختراق القياسى ومقاومة القص

غير الناشف لطبقة طينية صلدة

د . ماهر عطا الله

ملخص

عند تقصى حالة التربة فى موقع لمبنى عال يبلغ ارتفاعه 70 مترا فى مدينة بنغازى تم قياس مقاومة الاختراق القياسى لطبقة طينية صلدة تمثل الحامل الرئيسى لهذا المبنى وذلك فى عدة مواقع وعلى اعماق مختلفة . تنحصر هذه الطبقة مابين 10 امتار فوقها ويتواصل عمقها الى نهاية الحفر ولعمق 50 مترا تحت سطح الارض ، وتتكون الطبقة الفوقية من جزءين : طبقة من التراب المسمنت بسمك يتراوح مابين 2 و 4 امتار فوق الطبقة الطينية مباشرة تليها طبقة من التراب المسحوق . اما الطبقة الطينية نفسها فيبلغ متوسط معامل لدونتها 40٪ بينما تبلغ نسبة الطين فيها 50٪ ، ويقع مستوى المياه الجوفية على عمق تقريبى مقداره 1,3 مترا تحت سطح الارض .

تم فى هذه الورقة توضيح الزيادة فى معامل الاختراق القياسى ومقاومة الانضغاط غير المحصور ومقاومة القص غير الناشف مع التغير فى عمق الطبقة الطينية بناء على تجارب حقلية واخرى معملية . كما تم وضع الترابط بين مقاومة الانضغاط غير المحصور ومقاومة الاختراق القياسى لهذه الطبقة وتوصل الباحث الى وضع نسبة لها تبلغ 10 كيلو نيوتن / م^2 . ومن هذه العلاقة يمكن التنبؤ بمدى مقاومة الساق وتحمل الظرف النهائى للخوازيق كبيرة الاقطار.

CORRELATION BETWEEN SPT AND UNDRAINED SHEAR STRENGTH FOR A HARD CLAY LAYER

Maher Atalla*

SYNOPSIS

The standard penetration resistance is measured for a deep hard clay layer at several locations and depths in conjunction with the soil investigation for a tall building site in Benghazi. The clay layer with average plastic index 40 % and clay percent of 50 , is overlain by 10m of overburden composed of silty sand and a cemented sand layer from 2 to 4m thick just above the clay. Clay extends to the end of borings at 50m below the ground level. The G.W.L. is at about 1.3m from the ground level. The increase in the SPT N values , unconfined compressive strength and undrained shear strength with depth in clay is illustrated, then the penetration resistance is correlated with the unconfined compressive strength for the considered clay layer suggesting a ratio of the unconfined compressive strength to the SPT N value for this hard clay as 10 kN/m^2.

---

* B.Eng.(Civil) , Ph.D. , Associate Professor , Civil Engineering Department , Al-Fateh University , Tripoli/Libya.

Introduction

Soil investigation was carried out for a 70m tall building site in Benghazi. A detailed and comprehensive in-situ and laboratory testing was done accordingly. The main layer of interest is the stiff to hard clay layer overlain by about 10m overburden and extending till the end of the investigated depth at 50m below the ground level. For the used in this building large diameter bored piles, this clay layer is the main carrier of loads whether by shaft resistance or end bearing.

The present work is an attemp to correlate the standard penetration resistance measured by SPT and the undrained shear strength of the considered hard clay layer. Engineering properties of a similar soil material are less frequently -compared with cohesionless soils- investigated by using the SPT. However , using such testing as a practical useful technique in investigating "rock similar" materials is already considered as possible (Maher,1975,1981, Straud,1974, Cole and Straud,1976, Tomlinson,1976).

In-situ and laboratory soil testing

Sample borehole logs and SPT N values are given in Fig.1. The clay layer under consideration starts at about 10m depth of sand, silty sand and a cemented sand stratum of a thickness ranging from 2to4m just above the clay layer. Ground water level is at 1.2 to 1.5m from the ground level. The simple properties of the clay layer are as follows (average values) :

Specific gravity	2.71	Plastic limit	30 %
Unit weight	2.0 tf/m^3	Liquid limit	70 %
Natural water content	30 %	Plastic index	40 %
Clay content	50 %		

The natural water content for the clay layer is very close to the plastic limit line as shown in Fig. 1 , indicating the hard consistency of the material.

The drilling method is rotary drilling with 10m casing . Borehole diameter is 138mm. The SPT N values measured increase with depth in clay and have the range of values given in Table 1. Scatter of results is obvious and only an approximate correlation of N with depth in clay is attained in Fig, 2. For 85 % of results, the N values are about 25 at the top level of the clay layer and about 150 at 25m depth in clay (35m from G.L.) . Worth noting is the extrapolation of the measured number of blows corresponding to a certain penetration - measured to the nearest centimeter - to the value corresponding to 30cm penetration of the standard spoon. This extrapolation is made for N values exceeding 50. For example, if 50 blows correspond only to 15cm penetration, this is assumed to correspond to a value of N equalling 100. Furthermore, the N values less than 100 are left as they are while the values from 100 to 200 are approximated to the nearest 10 and values higher than 200 are approximated to the nearest 50. The "standard" technique is adopted i.e. the first 15cm penetration seating drive is not included in the estimation of N but the following 30cm (or part of it if N is higher than 50) are considered and the blows are counted.

Naturally, the carried out extrapolation is not essentially the real penetration resistance . However, it is regarded as a penetration resistance parameter. It is considered here that 50 blows/10cm is equivilant to an apparant penetration N value of 150. The auther is quite aware of the fact that such a proceedure can be considered as unreliable , but the whole thing of using the SPT in investigating the rock similar materials meets contraversial opinions. Limitations must be accepted and the need of care and judgement in the application of such a tool is emphasized.

During the borings, undisturbed samples were collected from the clay layer using thin walled tube samplers to be tested later in the laboratory . Samples dimentions for unconfined compressive strength and triaxial undrained shear strength are 3.8cm diameter and 7.5cm high. Table 1 shows the number of tests , values of the unconfined compressive strength q_u and double the value of undrained shear strength $2c_u$ to be combared with q_u .

Both the unconfined compressive strength and undrained shear strength show a tendancy to increase with depth in clay (Fig.3). Without a statistical approach , any interpretation of results shown in fig.3

could not be made due to the scatter of results and also taking into consideration that both q_u and $2c_u$ are compared and considered the same thing. The observed scatter in results could not be attributed to a definite reason but the inhomogenity of the material and the relative degree of disturbance could be considered as possible reasons. In the following analysis , only 90 % of results will be considered excluding the extremely deviated 10 % from both tails, i.e. from the minimum and maximum sides of the values considered.

Correlation of results

The SPT N values , unconfined compressive strength q_u and double the undrained shear strength $2c_u$ are all plotted for the considered 25m of the clay layer by adjusting the horizontal scales in Fig.4 to have the best correlation. In making this adjustment , an average value of N (50) corresponds to an average value of unconfined compressive strength (5 kgf/cm^2) for the investigated 25m depth . This suggests a correlation ratio of unconfined compressive strength to N value being 0.1 kgf/cm^2 (10 kN/m^2) , and a ratio of undrained shear strength to N value of 5 kN/m^2. Such a ratio ranged between 4 to 6 kN/m^2 in Stoud's (1974) tested materials termed as insensitive clays and soft rocks depending on the plasticity index.

Conclusions

A tendency of increase in N values, undrained shear strength and unconfined compressive strength with depth in clay is illustrated. Despite the considerable scatter of results it was possible to correlate reasonably -for 90 % of results- both the SPT and the unconfined compressive strength of a hard clay layer. The correlation ratio i.e. the ratio between the unconfined compressive strength to the N value is 10 kN/m^2. A further development of such correlation would be the use of SPT in the prediction of shaft resistance and end bearing of large diameter bored piles in hard clay.

The limitations or disadvantages of using the SPT in this study is the presence of thin layers of obviously harder rock which occured at various levels increasing substantially the estimated N value . Another limitation is that the found correlation factor is specific to the considered type of clay . Results must not be freely extrapolated to another hard clay.

References

Cole,K.W. and Stroud,M.A. (1976). Rock socket piles at Coventry Point Market Way, Coventry, Geotechnique, Vol.26 No 1.

Maher Atalla (1975). Standard penetration resistance of a marl layer, Al-Fateh University reports , Tripoli, (unpublished).

Maher Atalla (1981). Evaluation of engineering properties of soft shale for oil storage tanks site , Bulletin of the Faculty of Petroleum and Mining, Al-Fateh university, Vol.2, No 2.

Stroud,M.A. (1974). The standard penetration test in insensitive clays and soft rocks, Proc. European symposium on penetration testing , Stockholm.

Tomlinson ,M.J. (1976). Preface, Piles in weak rocks, Geotechnique, Vol. 26 No 1.

Acknowledgement

The auther thanks the Civil Engineering Department, Al-Fateh University for the kind permission to publish this work.

Table 1

SPT and Shear Strength Results

Test	No	Min	Max	Mean	Range of 90 % results
SPT N measurements	135	18	250	50	20 to 80
q_u , kgf/cm^2	8	0.72	10.15	5	2 to 8
$2c_u$,kgf/cm^2	12				

SPT - Standard penetration test

q_u - Unconfined compressive strength

$2c_u$ -Double the undrained shear strength

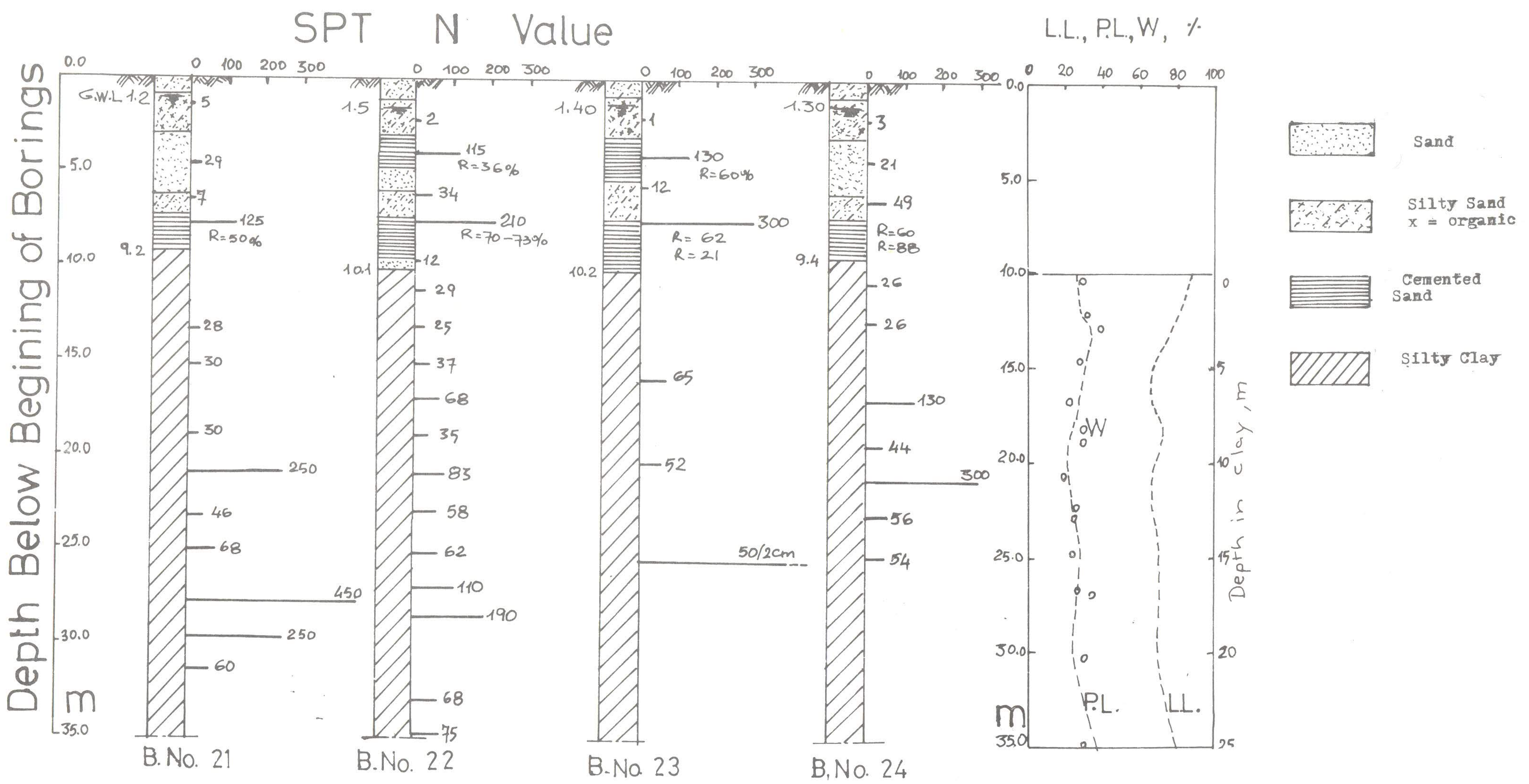

Fig. 1 Soil Profile and SPT N Values for Four Deep Borings

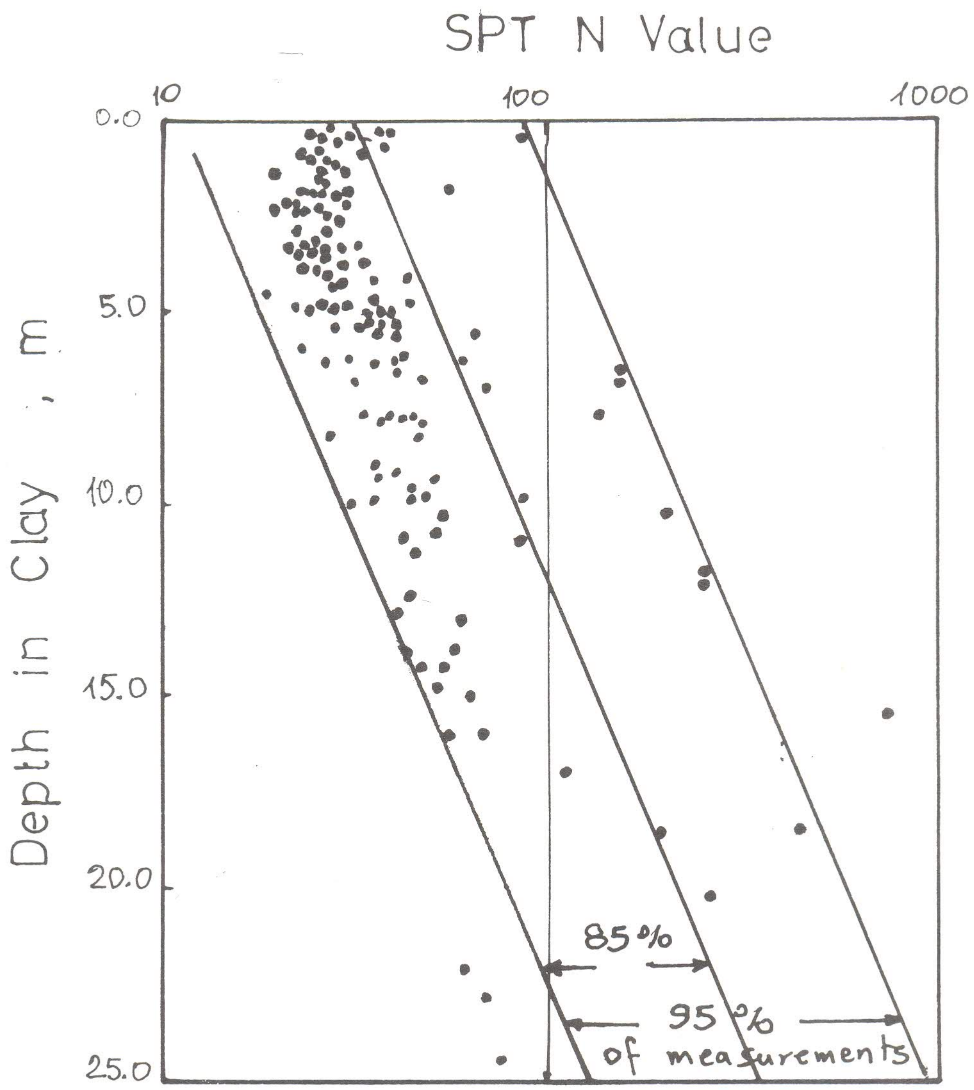

Fig. 2: Variation of N with depth in clay

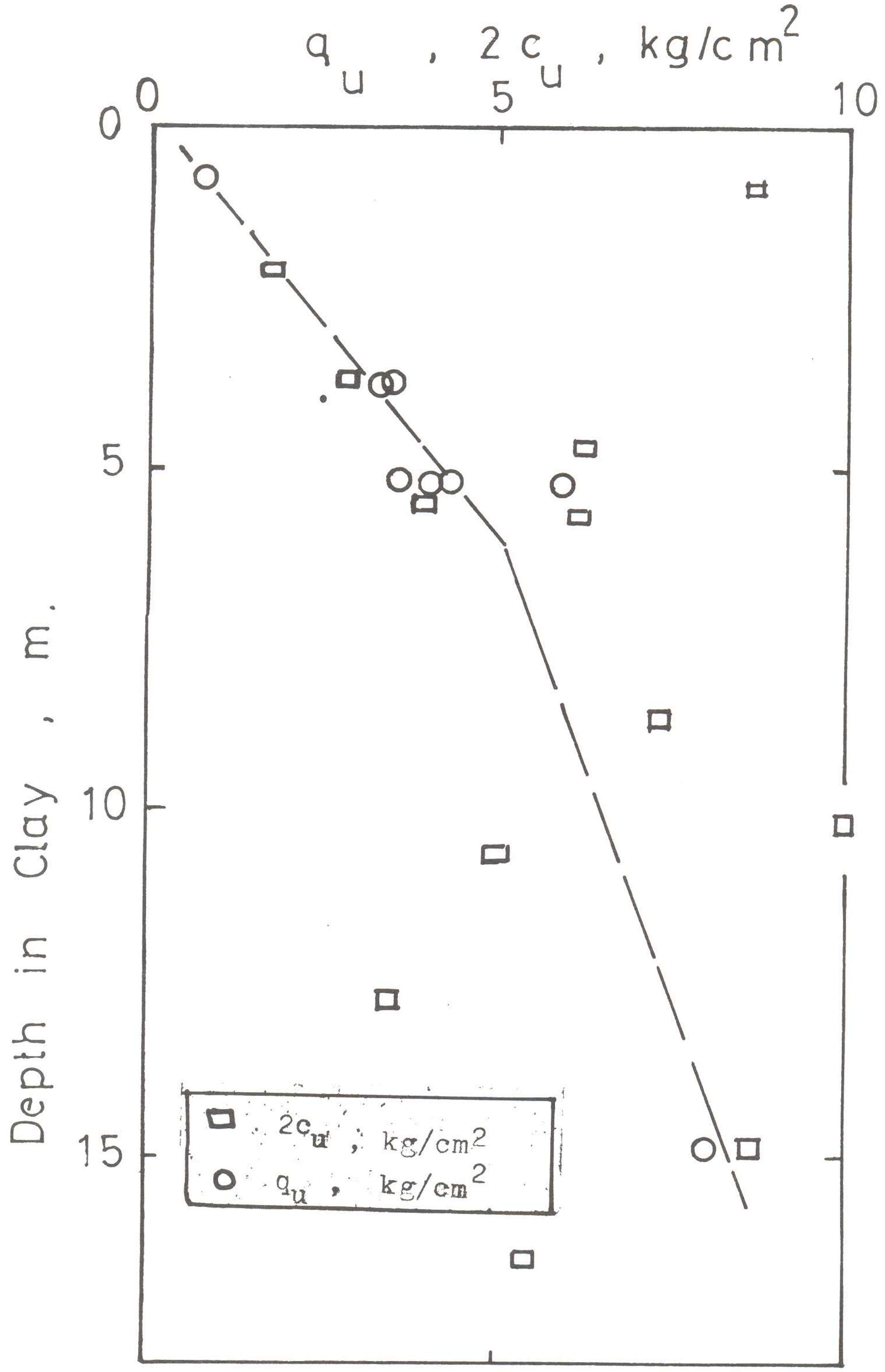

Fig. 3 : Scatter of the unconfined compressive strength and double the undrained shear strength with depth in clay

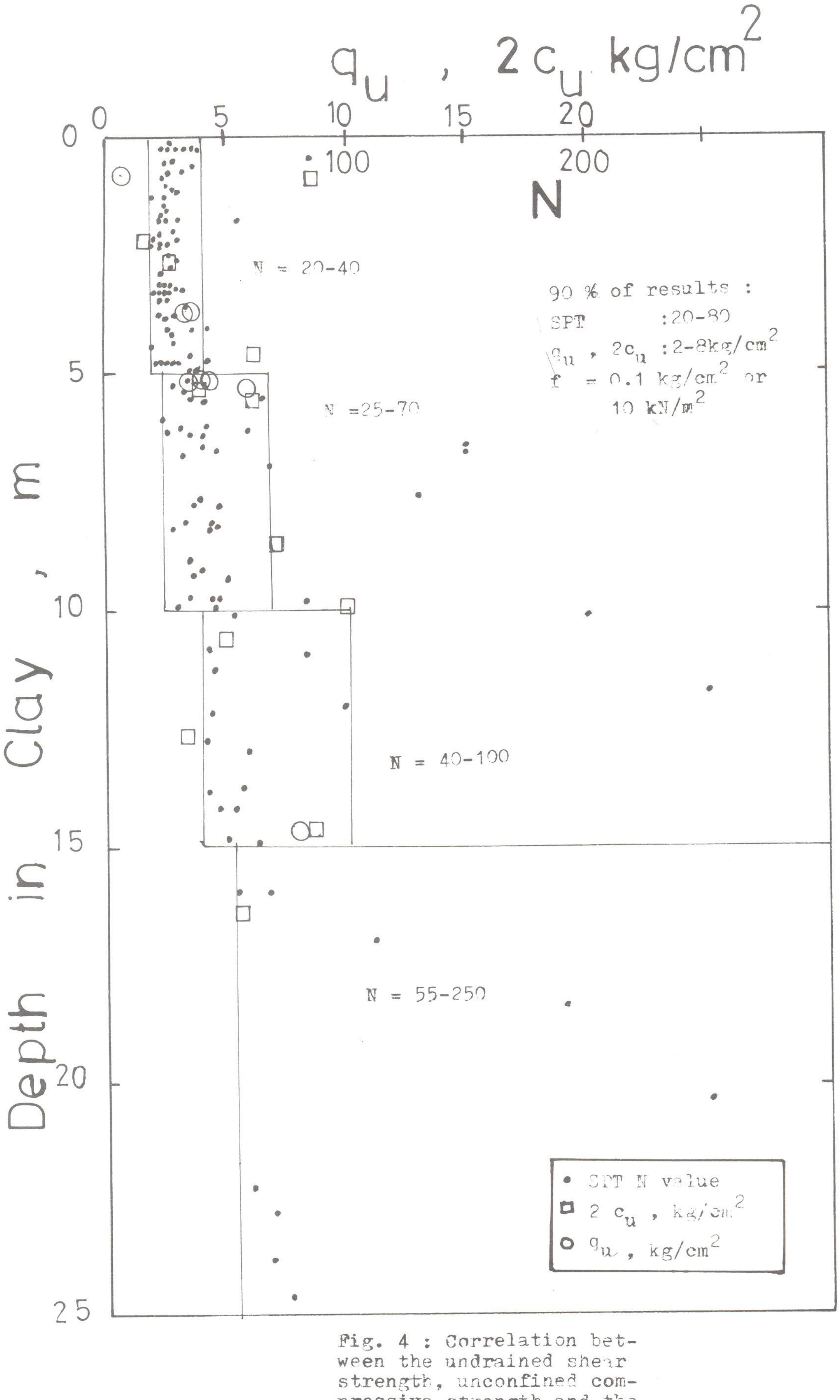

Fig. 4 : Correlation between the undrained shear strength, unconfined compressive strength and the SPT N value for the clay layer