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EVALUATION OF VARIOUS SOIL PARAMETERS OF Al-EMARA CITY FROM FIELD AND LABORATORY TESTS

Mudhafar K. Hameedi*

Assistant lecturer, Building and Construction Engineering Department, University of Technology, Baghdad, Iraq.

Abstract: This paper describes the geotechnical characteristic of soil located at Al-Emara city southern Iraq. The paper presents the data advanced from the field investigations performed at many projects at Al-Emara city. The ground conditions in the study area indicate that there is a deep layer (36 m) deep consisting of different soils. Namely, the records of boring exploration include the results of laboratory tests on samples taken from the site in addition to the results of field tests such as cone penetration tests, standard penetration tests. According to the test results and soil profiles, the stratification of layers was described for each borehole according to the test results. The paper aims at determination of mathematical correlations among the soil parameters determined from the laboratory and field tests from these relationships, several correlations were obtained from which prediction for geotechnical properties of various soils can be made. Several relationships were obtained from the field and laboratory properties of the soil, , the plasticity index, the preconsolidation pressure, cone penetration (cone resistance q_c, friction sleeve fs) with depth. The relationships include the relation between the standard penetration test number (N_{60}) and cone penetration resistance (q_c) ,sleeve resistance (fs), the relation between cone penetration resistance (q_c) and cohesion of soil (c) , the relation between cone penetration resistance (q_c) and angle of shearing resistance (Ø),The relation between cone penetration resistance (q_c) and undrained shear strength (c_u) .In addition the relationships include the relation between unconfined compressive strength (q_u) and constrained modulus of elasticity (D).

Keywords: *Correlations, soil, strength, plasticity, field tests, laboratory tests, Iraq.*

تقيم المعاملات المختلفة لتربة مدينة العمارة من الفحوصات الحقلية والمختبرية

الخلاصة: يصف هاذا البحث الخواص الجيوتقنية للتربة في مدينه العمارة جنوب العراق . يعرض البحث المعلومات التي تم الحصول عليها من التحريات الحقليه التي اجريت في العديد من المشاريع في مدينه العماره . ان خصائص التربه من منطقه الدراسه توشر وجود طبقه عميقه (بعمق ٣٦ م) مؤلفه من ترب مختلفه حيث تبين سجلات الاعمال الحفر وجود نتائج فحوصات مختبريه على نماذج اخذت من الموقع بلاضافه الى نتائج فحوصات حقليه مثل فحوصات اختراق المخروط وفحوصات الاختراق القياسي . واستناد الى نتائج الفحوصات وخواص التربه تم وصف طبقات التربه لكل حفره اختبارية بناءا على نتائج الفحوصات . يهدف البحث الى ايجاد علاقات رياضية بين خصائص التربة المستحصلة من الفحوصات المختبرية والحقلية حيث تم ايجاد العديد من العلاقات التي يمكن من خلالها تخمين الخواص الجيوتقنية لمختلف الترب . تم الحصول على العديد من العلاقات من الفحوصات الحقليه والمختبريه للتربه مثل مؤشر الدونه و اجهاد الانضمام السابق ومقاومه اختراق المخروط (مقاومة المخروط q_c ولاحتكاك السطحي f_s) مع العمق . ان هذه العلاقات تشمل العلاقه بين رقم الاختراق القياسي (N_{60}) و مقاومه المخروط (q_c) ومقاومه الاحتكاك السطحي (f_s) والعلاقه بين مقاومه المخروط (q_c) وتماسك التربه (c) والعلاقه بين مقاومه المخروط (q_c) وزاويه الاحتكاك الداخلي (Ø) والعلاقه بين مقاومه المخروط (qc) ومقاومه القص غير المبزوله (cu) . بلاضافه الى ذالك تضمنت العلاقات العلاقه بين مقاومة الانضغاط غير المحصور (qu) ومعامل المرونة المحصور (D) .

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* mthfar.algh@yahoo.co.uk

1. Introduction

If time and cost were not a problem, the design engineer could procure as many samples as necessary and execution as many laboratory or field tests as required to obtain a comprehensive understanding of subsurface soil and rock conditions. Engineering properties could be collected and any unreliable data could be excluded; further testing could then be started.

Unfortunately, time and costs are major problems and the geotechnical engineer must make right decisions at several steps during the design process to get the most reliable and acceptable soil characteristic information. The main step in obtaining these characteristics lies in the choice of a specific test and the translation of the test results in the design. For specified reasons (e.g., budget, difficulties in sampling, etc.), it is not easy to procure the required parameter(s) of interest.

Fortunately, the geotechnical engineer can often use well-known and/or site-specific correlations to get the desired property or parameter. Also, correlations are beneficial as a quality assurance validation on test results determined from the exploration.

A Field study by Y. Suzuki et al. (1995). Correlations between liquefaction resistance and cone penetration resistance of sandy soils are examined. The comparison of the CPT data with the soil properties of the in situ frozen samples has shown that: (1) Robertson's soil classification chart performs well for sandy soils in Japan; (2) the CPT q_c value shows a good correlation with elastic shear modulus of the in situ frozen samples; and (3) the liquefaction resistance of the in situ frozen samples is uniquely expressed if the cone penetration is normalized in terms of confining pressure and minimum void ratio.

A field and laboratory evaluation of soft clay southern Iraq was carried out by Fattah et al. (2006). The study presented the geotechnical properties of normally consolidated Garmat Ali clay which is located at the intersection of the Tigris and Euphrates rivers southern Iraq, to form Shatt Al –Arab river which is flowing southward reaching the Arabian Gulf. The ground conditions in this area showed that there exists a deep layer (15 m deep) of soft clay. Several correlations were derived from the field and laboratory characteristics of the soil. These relationships include the relation between the number of standard penetration test (N) and the field cone resistance, the pastconsolidation pressure and the field vane shear strength, relation between horizontal and vertical permeability, and the plasticity index and the undrained shear strength (Su). From these correlations, several relationships were derived from which estimation for geotechnical characteristics of soft clays could be made. The relationships obtained between the studied soil characteristics including, plasticity index, undrained shear strength measured by vane shear test, standard penetration number, pastconsolidation pressure σ_p' , field cone resistance (q_c) and permeability are acceptable when compared to the relationships of other soils. The ratio of strength, which is defined as (Su /σp') or (Su/N) or (q_c / N), increases with the plasticity index, but the angle of internal friction slightly decreases with the increase in plasticity index.

The engineering characteristics of the top surface layer on very soft clay of the south coast in Korea were studied by Jung et al., (2006). The very soft clay layer in the south coast area was evaluated to determine the engineering properties of in situ clay and dredged reclaimed clay by different testing methods. Comparison was made among the results obtained by the field standard penetration test, field vane shear test, piezocone penetration test and dynamic cone penetrometer test.

The statistical analysis studied by Al-Kahdaar R., M., and Al-Ameri F., I. (2010).Used geotechnical characteristic of Al Emara soil from about 40 boreholes taken at different locations within Al Emara city. The statistical analysis by Microsoft office software. This research is devoted to study the correlation between several physical properties such as (LL, PI, LI, w_n, γ_τ, e_0) with several mechanical properties such as (q_u, cc, cs, SPT).

Afield study presented by Karray et al. (2011) establish a relationship between normalized shear wave velocity, Vs, normalized tip resistance, qc, and mean grain size, D_{50}. Using the Péribonka project data gained on fully coarse sands in conjunction with the Canadian Liquefaction Experiment (CANLEX) project data gained on fine sands has proven effect of particle-size distribution on the relationship between Vs and q_c. The research proposes a correlation between Vs, qc, and D_{50} for uncommented and Holocene-age granular soils in continuity with the relation developed by Wride et al. from the CANLEX project.

The accuracy or use of relationships to obtain the soil properties is justified and recommended in the following conditions (Sabatini et al., 2002):

(1) Specific information are simply not available and are only available by indirectly comparing to other characteristics;

(2) A limited quantity of data for the specific characteristic of interest are available and the correlation can give additional values to these limited data; or

(3) The validity of any data is in question and a comparison with previous test results provides the accuracy of the selected test to be validated. Correlations in general must never be adopted as a substitute to the actual subsurface investigation program, but rather to complement and validate specific information related to a project.

2.**Data Selection**

The objectives of the percent study are to determine correlation among soil properties which can be adopted for design purpose. The chosen data was gained from soil investigations major oilfield projects on Al Emara southern Iraq. The ground conditions in the study area showed the presence of a deep layer (36 m deep) composed of different soils. More than 120 SPT profile and 40 CPT profile were obtained. The closest available testing locations were selected to build the SPT – CPT correlations for each site. Locations of sites are shown in Table 1.

Table 1: Site locations.

No.	Project	Site	City
1	Cpf2	Halfaya oil field	Al Emarah city
2	GRS	Near Khlaa city	Al Emarah city
3	HPS	Halfaya oil field	Al Emarah city
4	BUT	Bazerkan field	Al Emarah city

Three parameters are considered representative of the data field used in this study, SPT N (blows/0.3m), CPT tip penetration resistance (q_c) and skin resistance (fs). The data also included SPT boring log, soil cohesion (c) , angle of shearing resistance (ϕ),undrained shear strength (c_u) , unconfined compressive strength (q_u), preconsolidation stress, the plasticity index. Each boring log contained a soil profile with soil type classifications according to the Unified Soil Classification System (USCS); based on laboratory tests (i.e., sieve analysis, and Atterberg limits).

3. Analysis of Test Results

The variation of plasticity index with depth is shown in Figure 1which decides that the clay layers of the region are of high plasticity. Figure 2 shows the distribution of both the effective overburden and preconsolidation pressures with depth. Figure 3 presents the variation of the standard penetration number (N_{60}) with depth.

It is noticed from Figure 2 that the top soil up to about 7.0 m is coverconsolidated since the preconsolidation pressure is greater than the effective overburden pressure. This may be caused by drying of the top layers due to direct exposure to sun rays.

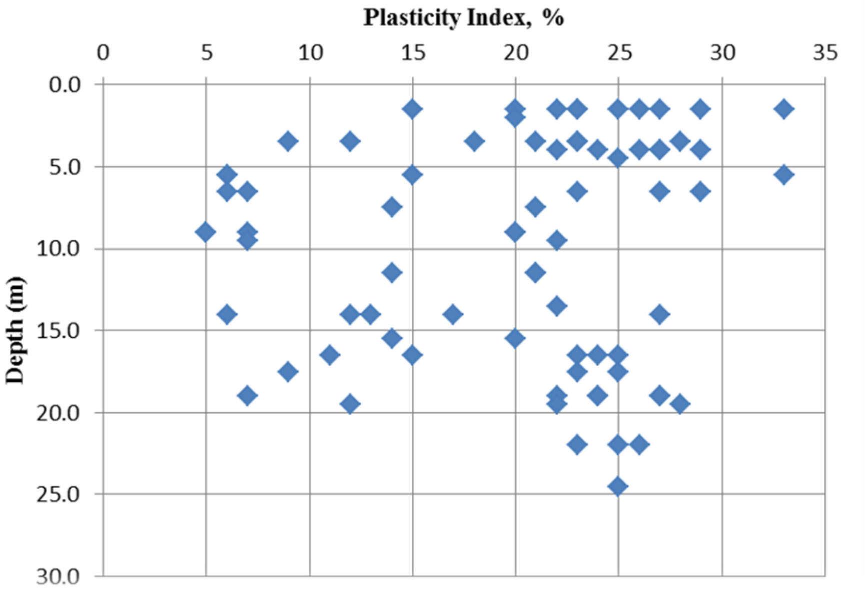

Figure 1 Variation of the plasticity index with depth.

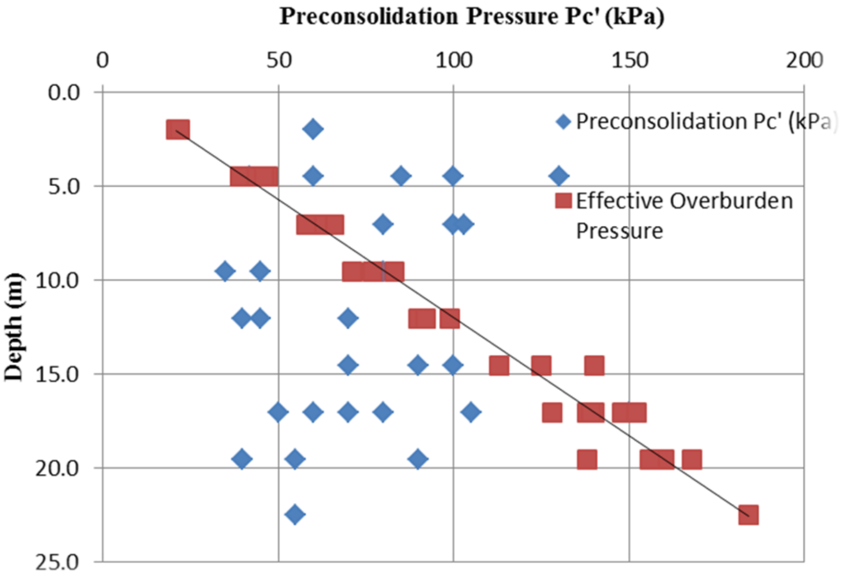

Figure 2. Distribution of the effective overburden and preconsolidation pressures with depth.

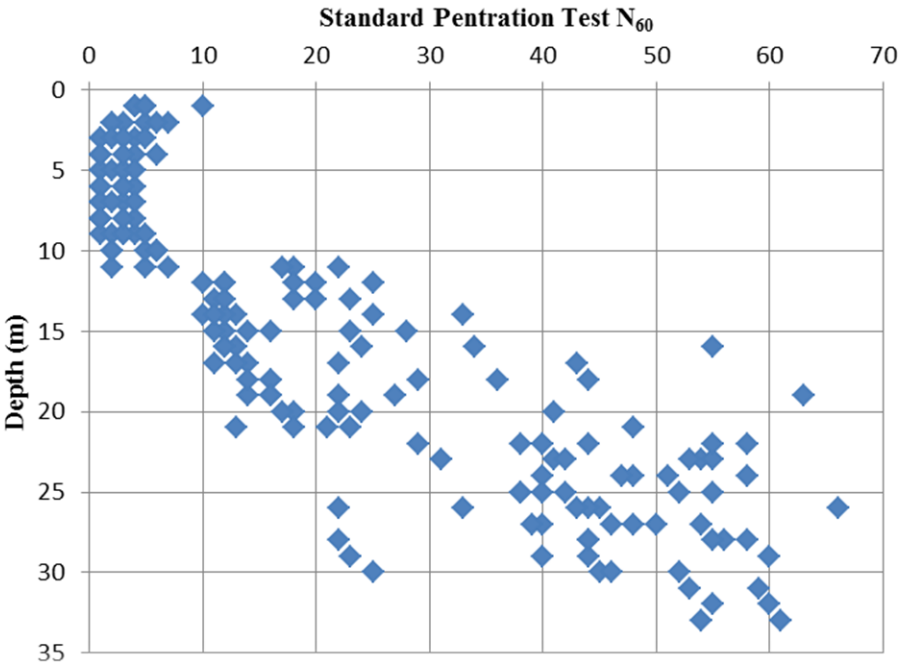

Figure 3. Distribution of standard penetration number N_{60} with depth.

Figures 4 and 5 present the variation of the cone penetration resistance, (q_c) and sleeve resistance, (Fs), respectively with depth.

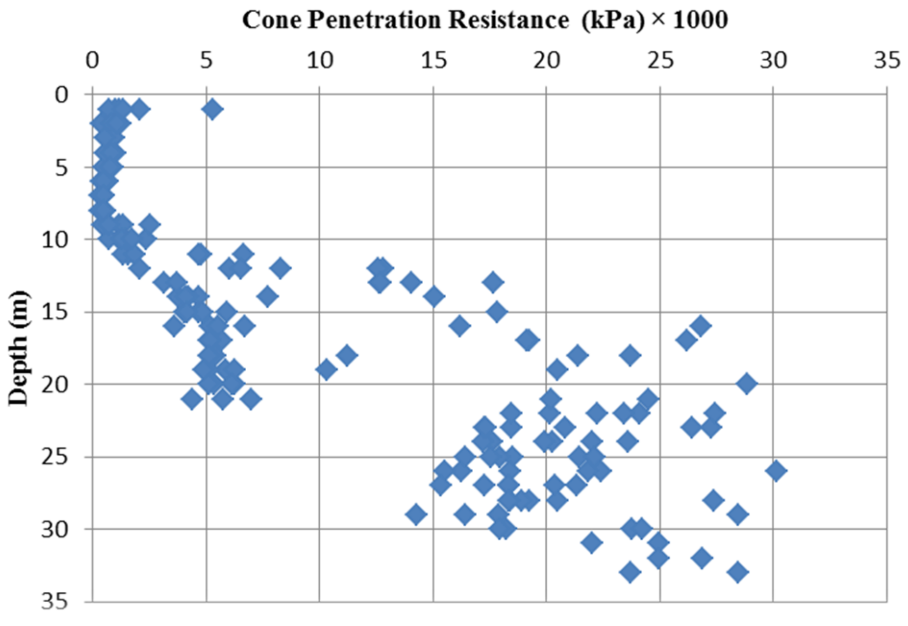

Figure 4 Distribution cone penetration resistances (q_c) with depth.

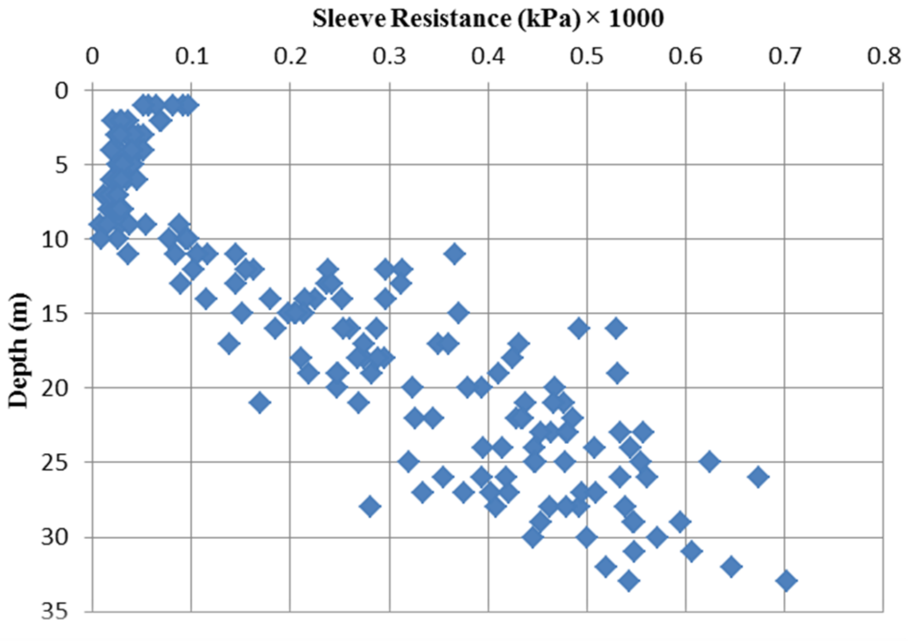

Figure5. Distribution sleeve resistance (fs) from cone penetration test with depth.

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The program Excel is used to build the required relationships. Figure 6 show a relationship between the standardpenetration number(N_{60}) and cone penetration resistance (q_c), thefollowing relationship can be obtained with coefficient of determination

$$q_c = 0.4562\,N_{60} - 0.0361 \qquad (1)$$

where q_c is in kPa and N_{60} (blows/0.3m).

Figure 7 shows a relationship between the standard penetration number (N_{60}) and sleeve resistance (fs), from which the following relationship is obtained with $R^2 = 0.87$:

$$Fs = 0.0176 \, (N_{60})^{0.8635} \qquad (2)$$

where Fs is in kPa and N_{60}(blows/0.3 m).

Figure 8 show a relationship between the cone penetration resistance (q_c) and the angle of shearing resistance (Ø), from which the following relationship can be obtained with $R^2 = 0.84$:

$$Ø = 1.4758 \, q_c + 3.3932 \qquad (3)$$

Where Ø is in degrees and q_c in (kPa).

Figure 9shows a relationship between the cone penetration resistance (q_c) and cohesion of soil (c), the following relationship can be obtained with R^2= 0.85:

$$c = 1.7972 \, q_c + 9.9082 \qquad (4)$$

where:

c: cohesion of soil, result from direct shear test, kPa

q_c: cone penetration resistance ,kPa

It can be seen that there is a linear relationship between the cone penetration resistance and cohesion of soil

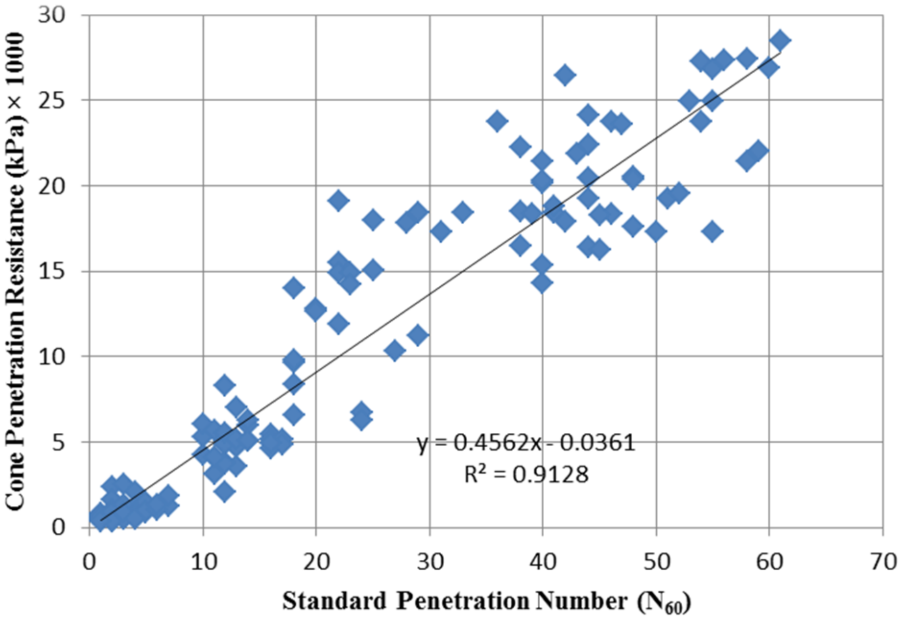

Figure 6 Relation between the standard penetration number (N_{60}) and cone penetration resistance (q_c).

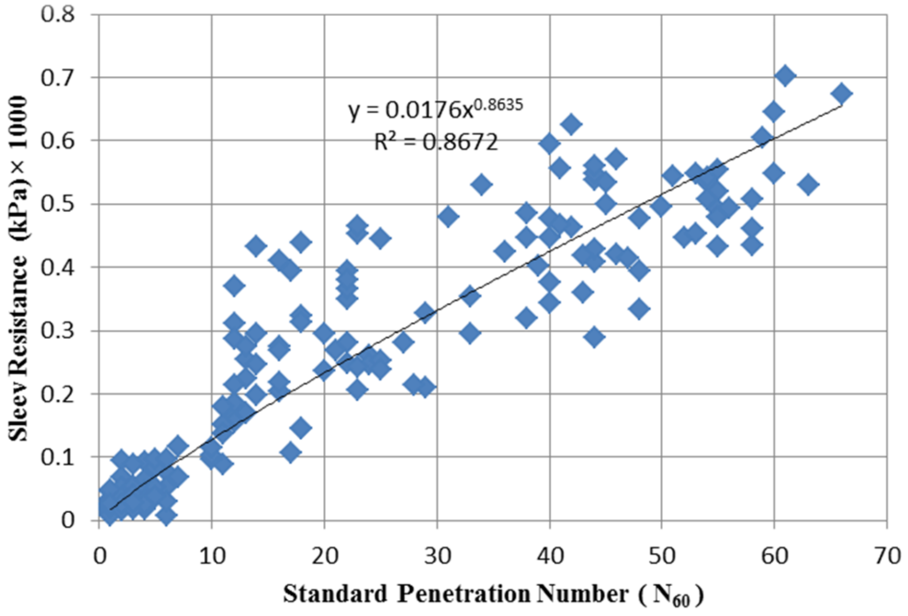

Figure 7 Relation between the standard penetration number (N_{60}) and sleeve resistance (fs) from cone penetrationtest.

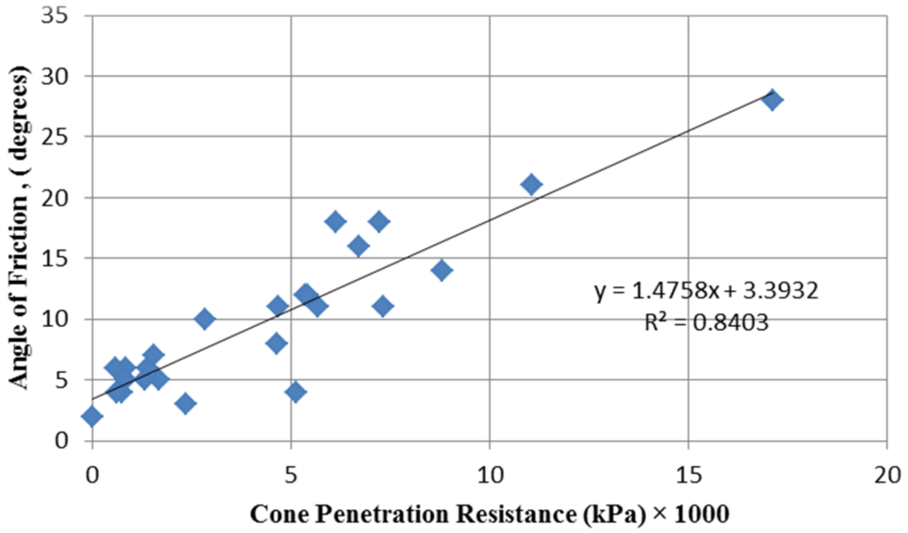

Figure 8 Relation between the conepenetration resistance (q_c) and the angle of shearing resistance (Ø).

Figure 10shows a relationship between the cone penetration resistance (q_c) and the undrainedshear strength (C_u),the following relationship can be obtained with $R^2 = 0.83$:

$$C_u = -8.6983\, q_c^2 + 137.76\, q_c + 44.973 \qquad (5)$$

where:

C_u:undrained shear strength, $q_u/2$,kPa

q_c :cone penetration resistance . kPa

q_u: unconfined compressive strength , kPa

Figure 11 shows a relationship between the unconfined compressive strength (q_u) and constrained modulus of elasticity (D) obtained from odometer test, the following relationship can be obtained with $R^2 = 0.86$:

$$q_u = 127.57D^2 - 738.22D + 1233.3 \qquad (6)$$

where:
D : the constrained modulus = $1/m_v$
m_v: coefficient of volume change , m^2/kN
q_u: unconfined compressive strength , kPa.

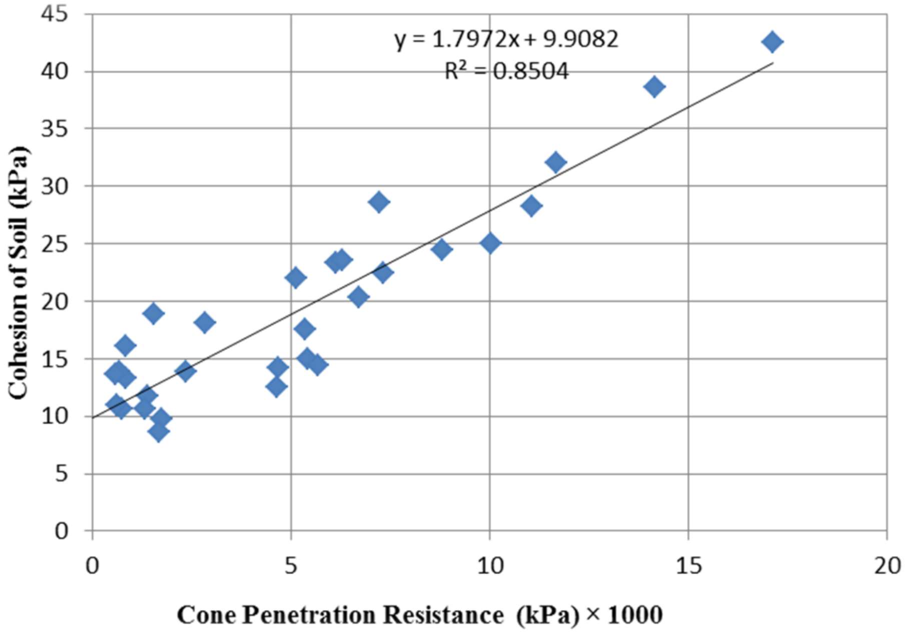

Figure9.Relation between the cone penetration resistance (q_c) and cohesion of soil.

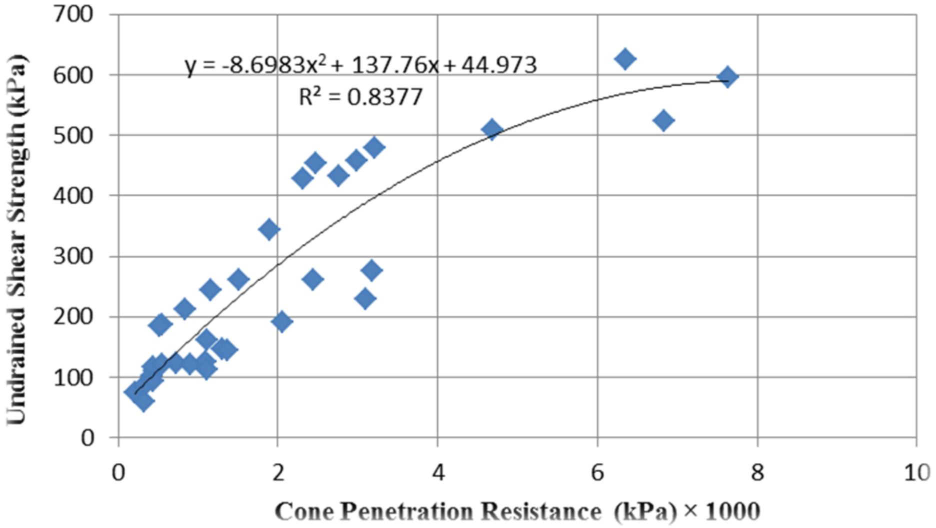

Figure10.Relation between the cone penetration resistance (q_c) and undrained shear strength (c_u).

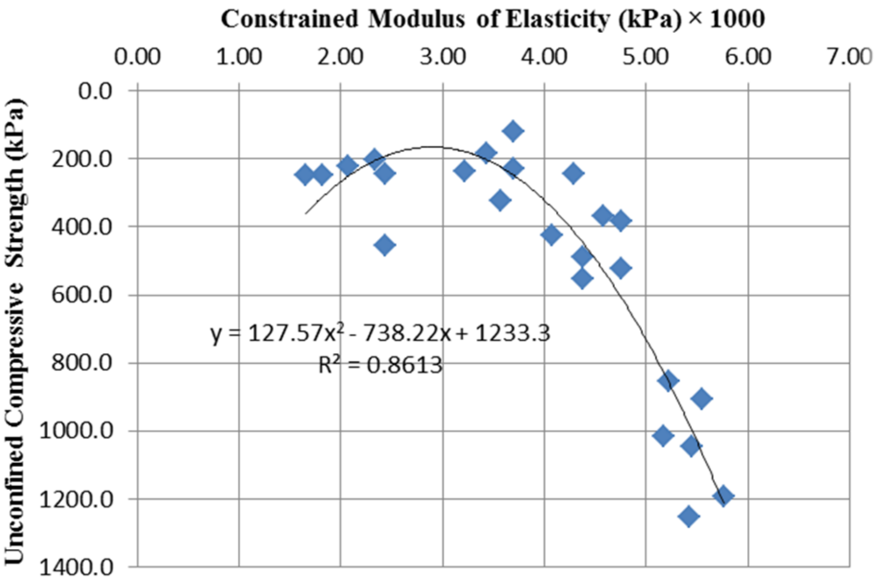

Figure11.Relation between the constrained modulus of elasticity (D) and unconfined compressive strength (q_u).

4. Conclusions

1. The top soil of Al Emara city up to about 7.0 m is coverconsolidated since the preconsolidation pressure is greater than the effective overburden pressure. This may be caused by drying of the top layers due to direct exposure to sun rays.
2. There is a unique correlation between the cone penetration resistance and the undrained shear strength, angle of friction and the standard penetration number.
3. A number of correlations could be obtained from analysis of the field and laboratory measured soil properties with good coefficients of determination. The correlations included relation between the standard penetration number (N_{60}) and cone penetration resistance (q_c), relation between the standard penetration number (N_{60}) and sleeve resistance (fs), relation between the cone penetration resistance (q_c) and the angle of shearing resistance (ϕ), relation between the cone penetration resistance (q_c) and cohesion of soil (c), relation between the cone penetration resistance (q_c) and the undrained shear strength (C_u) and relation betweenthe unconfined compressive strength (q_u) and constrained modulus of elasticity (D) obtained from odometer test**.**

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