CORRELATIONS BETWEEN PHYSICAL AND MECHANICAL PROPERTIES OF AL-AMMARAH SOIL IN MESSAN GOVERNORATE

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ABSTRACT:

This paper describes the geotechnical properties of Al-Ammarah soil of Ammarah city in Messan Governorate-southern parts of Iraq. Data and other information taken from numbers of geotechnical reports that performed under the supervision of Consulting Engineering Bureau of Baghdad University. This research is devoted to study the correlation between different physical properties such as (LL, PI, LI, ω_n,γ_t, e_o) with different mechanical properties such as (q_u, c_c, c_s, SPT). The correlation is verified using simple regression analysis. From the regression results it was found that there is direct correlation between different parameters. By using the correlation-with some information- preliminary investigation stages and studies of any structure can be performed to find indicative design parameters.

الخلاصة:

تم في هذا البحث وصف الخصائص الهندسية لتربة مدينة العمارة في محافظة ميسان. في هذا البحث تم الاستفادة من المعلومات والبيانات المتوفرة من التقارير الصادرة من مكتب الأستشارات الهندسية التابع لجامعة بغداد والأستفادة منها في تخمين بعض العلاقات بين الخصائص الفيزيائية (LL, PI, LI, ω_n ,γ_t, e_o) والخصائص الميكانيكية (q_u, c_c, c_s, SPT) باستخدام التحليل الأحصائي. أن هذه العلاقات مهمة في مرحلة الدراسة والتخطيط والتصميم الاولي لاي منشأ وبأستخدام هذه العلاقات يمكن اعطاء مجموعة من المعاملات الخاصة بالتصميم دون الحاجة لاجراء تحريات تربة تفصيلية.

KEY WORDS: Ammarah city, Liquidity index, Plasticity index, Unconfined compressive

strength, Natural water content, simple regression.

NTRODUCTION:

Ammarah city is a land which subjected periodically to erosion and accumulated fluctuation of the sea. The thickness of sediments that consists of clayey silt to silty clay is about (150-200)m. The bearing capacity at shallow depth is ranging from (6-8) ton/m^2, the area imposes high water table

between (1-3)m below nature ground level. In general the area consist of an erratic distribution of the layers at shallow depth. This is may be attributed to the nature of the area which can be described as a recent sediments (Buringh, 1960).

This study use geotechnical properties of Ammarah soil from about 40 boreholes taken at different locations within Ammarah city as shown in Figure (1). All data was taken from geotechnical reports performed by the CEB. Some of these reports and investigations were made by or under the supervision of the researchers. Any unusual data and test results have been excluded from the analysis. The statistical analysis was made using simple regression analysis using Microsoft office software.

GEOLOGY OF MISSAN

Millions of years ago, Iraq was laying in a large hollow part of the surface called the Tethgs geosyncline. It was submerged by the sea and bordered by plateaus and tablelands.

The youngest geological process is the sedimentation of fines material of loamy sand, silt and clay in the extensive lower Mesopotamia plain, a process which still continuous at present time.

The surface of the area covered with recent of flood plain deposit by Tigris with some sediments came by air as dust during the end of spring and the beginning of summer. The recent sediment is of silt clay, and some fine sand. The light minerals consists of carbonate (20% - 30%) quarts, Albite, clay minerals as montmorllionite and some gypsum and halite because of arid climate of Al-Ammarah.

Because of an advantages geographic position and morphological situation the basin of the Mesopotamia plain was most probably subjected to periodically repeating phases of accumulation and erosion in accordance with the periodical fluctuations of the sea level caused by the cyclic changes during Pleistocene. The thickness of the sediments is about (150-200)m.

Marine in layers were described at Hammar formations. The formation is composed of sand and silts in its lower part and clay in the upper part. The formation is up to 20m thick and is distributed south wards from Ammarah as far as Zubair and Nahr Omar (Buringh, 1960) as shown in figure (2).

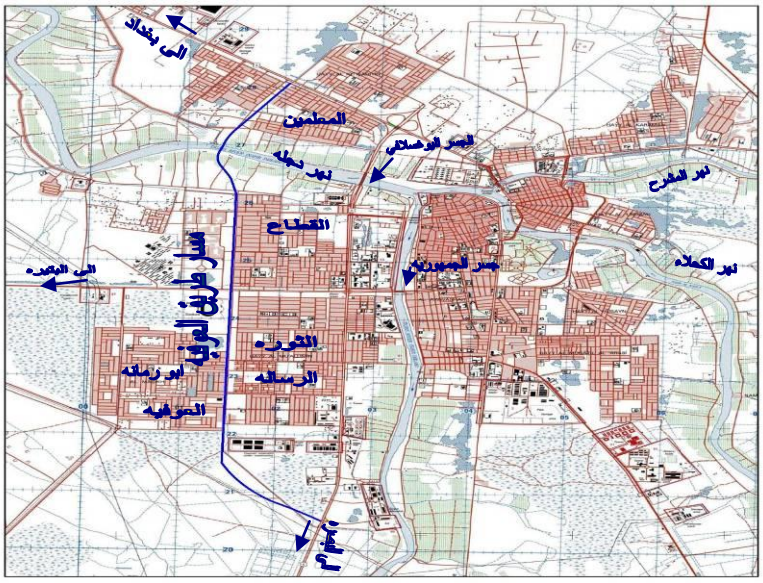

Figure (1) Administrative Map of Al-Ammarah city.

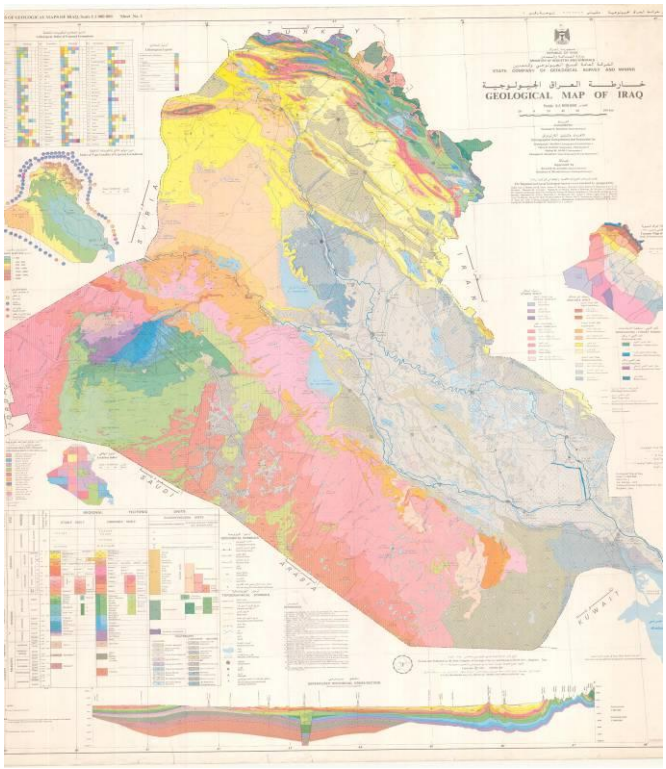

Figure (2) Geological Map of Iraq

PREVIOUS WORK

In the last decay, many research was performed to correlate the physical properties with the mechanical properties. This approach was adopted for the purpose of time saving and reduce cost of investigations. This approach was adopted from the earlier researcher in the filed of soil mechanics and foundation engineering. Some of these correlations are listed in Bowles (1996). However, the following are some of the present works.

In (1982) Abdel-Rahman has made correlation between index tests and the engineering properties of Egyption clay from different locations along the Nile valley and Delta.

In (1994) Khamehchiyan and Iwao studied the properties of Ariak soft clay (the most problematic soil in Japan). They made intensive study on its geotechnical properties and make a correlations between physical and mechanical properties with simple regression and multiple regression analysis in spite of the simple regression were enough for estimating.

Isik Yilmaz (2000) perform another study to evaluate the shear strength of clayey soil by using the liquidity index from various locations in Turkey.

On the other hand; USDA published a data and make a correlation between soil plasticity as well as plasticity index and strength parameter (residual strength) (USDA, 2004).

Al-Busoda (2009) evaluate and correlate between physical and engineering properties of Baghdad cohesive soil based on Atterberg limits and unit weight tests.

GEOTECHNICAL PROPERTIES OF Al-AMMARAH SOIL.

Physical Properties

The collected physical and mechanicsl properties of Al-Ammarah silty clay soil is presented in Table (1). The plasticity chart is shown in Figure (3); the relation between plasticity index PI, and liquid limit LL, is shown in Figure (4).

Table (1) The soil properties of Al-Ammarah soil

Soil properties	Range
Physical properties:	
Gs	**2.62-2.82**
Void ratio e	**0.687-0.998**
Liquid limit	**22-62**
Plasticity Index	**5-34**
Liquidity Index	**0.43-2.78**
Natural water content	**10.27-39.2**
Total unit weight (kN/m^3)	**18.29-20.17**
Mechanical properties:	
SPT	**3-50**
Unconfined compressive strength (kN/m^2)	**44.0-296.6**
Compression index	**0.125-0.458**
Swelling index	**0.016-0.043**

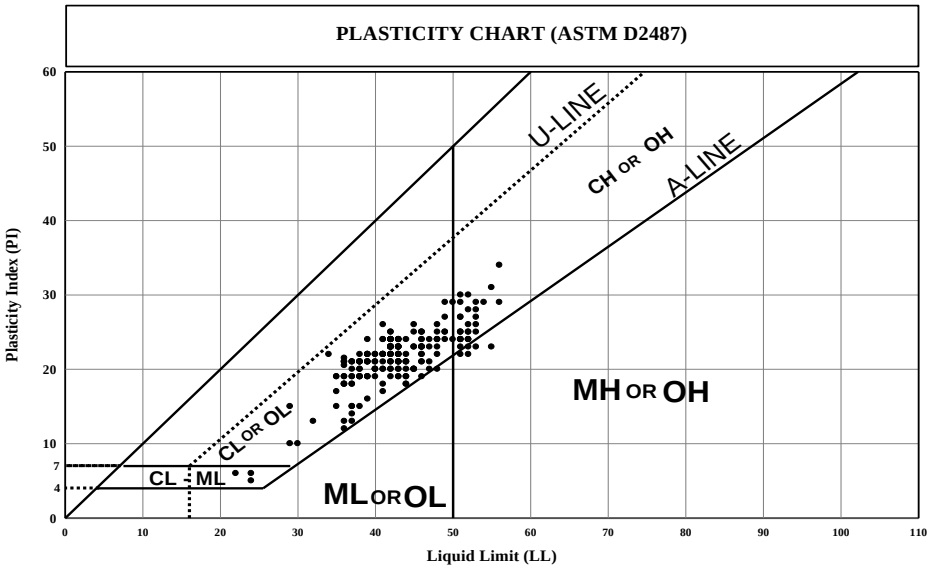

Figure (3) The Unified Soil Classification chart for Ammarah soil.

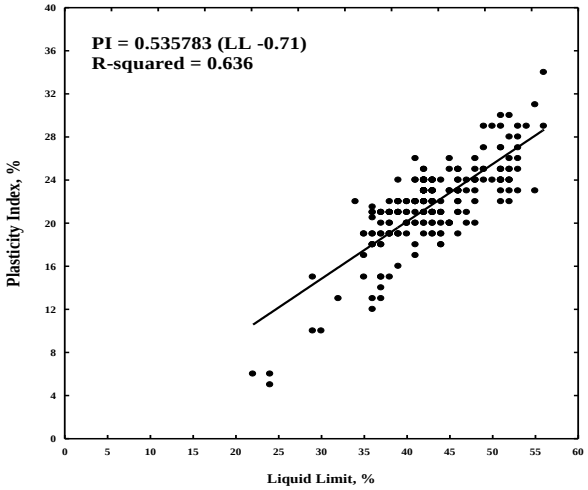

Figure (4) Relation between plasticity index and liquid limit.

From these figures it can be seen that all the cohesive soil-according to USCS-at the investigated area are clayey soil with low to high plasticity (CH to CL). To compare these results with the plasticity chart; Figure (4) was drawn. From this figure it can be seen that the fitting line can be described by the following equation:

$$PI = 0.536\ (LL-0.71) \quad (1)$$

While the equation of the A-Line is **[PI = 0.73 (LL-10)]**

The relation between total density and initial void ration is presented in Figure (5). The correlation for this figure can be given by the nonlinear equation with correlation coefficient of 0.811:

$$\gamma_t = 30.28 - 21.46\, e_o + 10.17\, e_o^2 \quad (2)$$

The relation between initial void ratio e_o and natural water content ω_n is given in Figure (6) and can be represented by the following equation with correlation coefficient equals 0.945.

$$e_o = 0.025\, \omega_n + 0.078 \quad (3)$$

4.2 MECHANICAL PROPERTIES

The summary of the ranges for mechanical properties of Ammarah city are presented in Table (1). Single regression analysis was adopted to obtain the relations between mechanical properties and physical properties of Ammarah city**.**

- ***COMPRESSIBILITY***

The variation of swelling index c_s with compression index c_c is presented in Figure (7) and this variation can be represented by the following equation with a correlation coefficient of 0.97.

$$c_s = 0.091\, c_c \quad (4)$$

Equation (4) satisfies the variation of c_s with c_c for most clayey soils. Bowles (1996) stated that c_s=0.05 to 0.10 c_c.

The relation between compression index c_c and liquidity index LI, is shown in Figure (8). This variation can be described by the following equation with correlation coefficient of 0.61 as.

$$c_c = 0.24\, LI + 0.21 \quad (5)$$

In Figure (9) the relation between compression index and natural water content. This relation can be written by the following equation with correlation coefficient of 0.946.

$$c_c = 0.0092\, \omega_n \quad (6)$$

The relation between swelling index and natural water content is shown in Figure (10) with a correlation coefficient of 0.975.

$$c_s = 0.00087\, \omega_n \quad (7)$$

The relation between compression index and liquid limit as shown in figure (14) with coefficient of 0.868, when compared this equation with correlation equation of Terzaghi and Peck its found that the curve run above Terzaghi line.

$$c_c = 0.00556\, LL \quad (8)$$

$$c_c = 0.009\, (LL-10) \text{ (Terzaghi and Peck)} \quad (9)$$

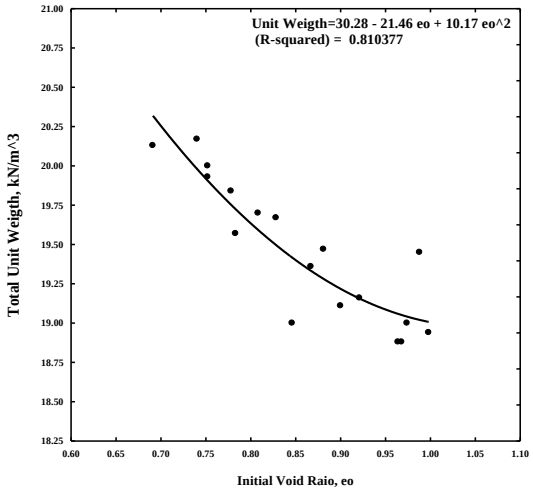

Figure (5) Relation between total unit weight and initial void ratio.

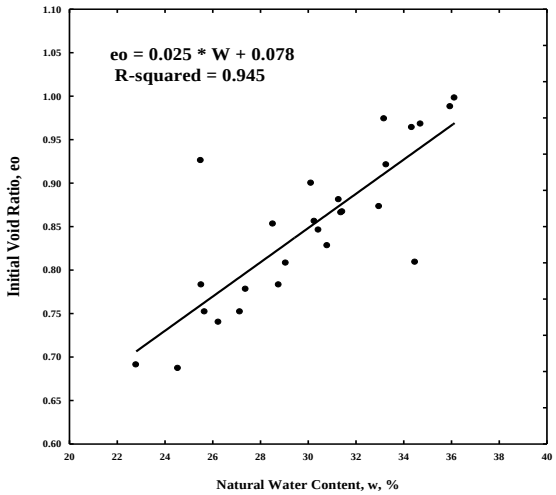

Figure (6) Relation between initial void ratio and natural water content.

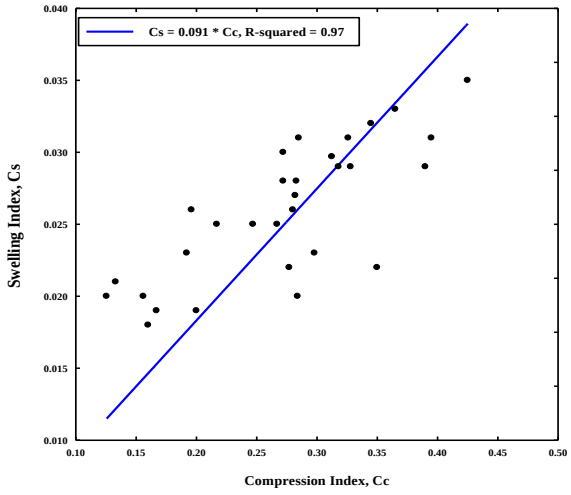

Figure (7) Relation between swelling index and compression index.

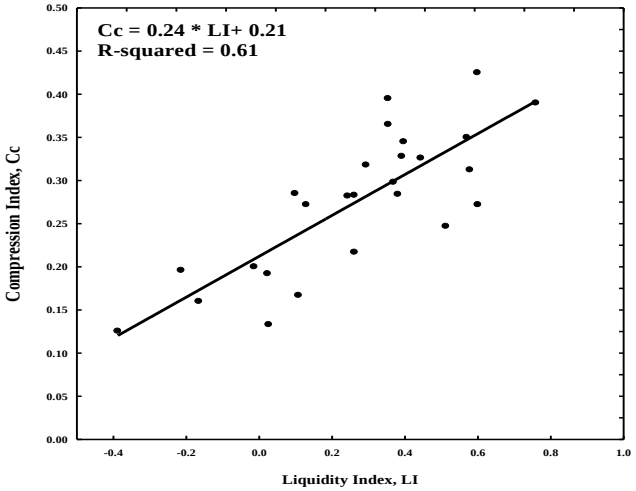

Figure (8) Relation between Compression index and Liquidity index.

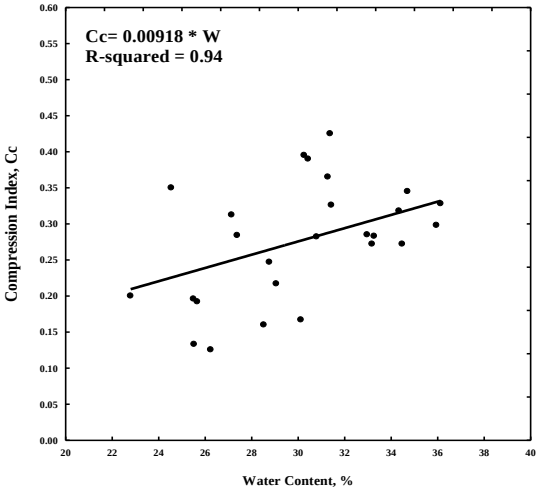

Figure (9) Relation between compression index and natural water content.

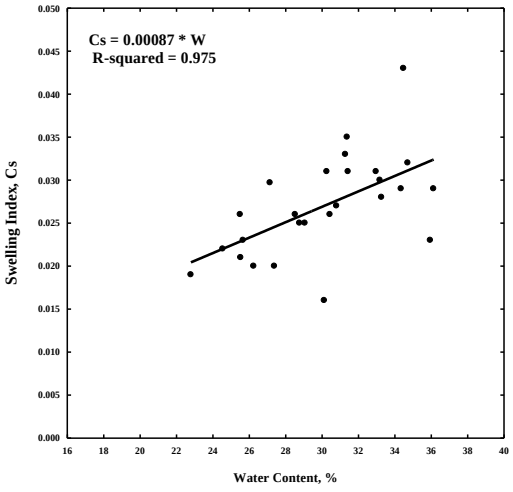

Figure (10) Relation between swelling index and natural water content.

Unconfined Compressive Strength

The shear strength of a soil is the internal resistance per unit area that the soil mass can offer to resist failure and sliding along any plane inside it. Therefore, the engineer should understand the nature of shearing resistance in order to analyze soil stability problems such as bearing capacity, slope stability and lateral pressure on earth retaining structures (Das, 2002).

The shear strength parameters dependent on type of laboratory test, previous stress history, particle packing, grain shape and water table, one of the tests that obtained from it the shear strength helping for obtained the bearing capacity that used in design is unconfined compression test. With these considerations, from figure (11) the relation between unconfined compressive strength qu and liquidity index LI, with correlation coefficient 0.53.

$$qu = 186.3-172.5\ LI + 24.2\ LI^2 \quad (10)$$

The relation between unconfined compressive strength to standard penetration test qu /SPT to plasticity index PI, with coefficient of 0.872 as shown in figure (12).

$$qu/SPT = 0.186\ PI \quad (11)$$

From figure (13) the relation of qu to standard penetration test SPT with coefficient of 0.898.

$$qu = 4.24\ SPT \quad (12)$$

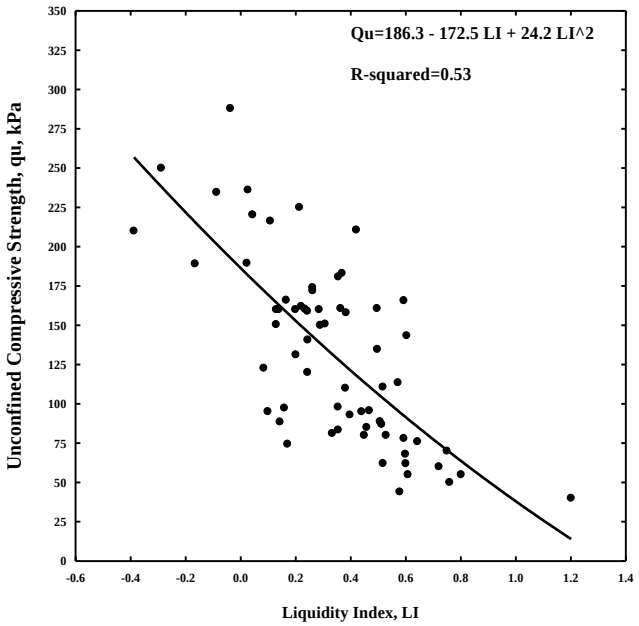

Figure (11) Relation between unconfined compressive strength and liquidity index.

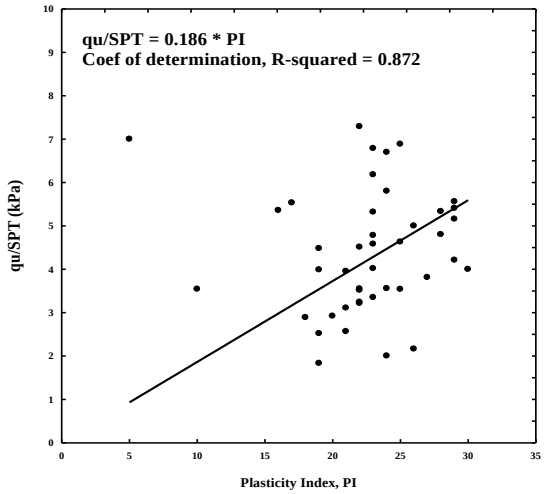

Figure (12) Relation between unconfined compressive strength to standard penetration test and plasticity index.

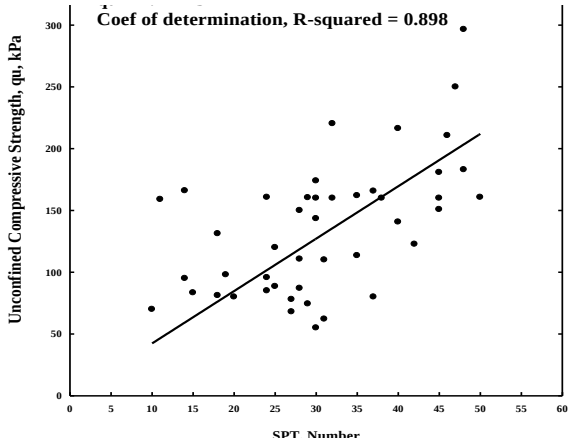

Figure (13) Relation between unconfined compressive strength and standard penetration test.

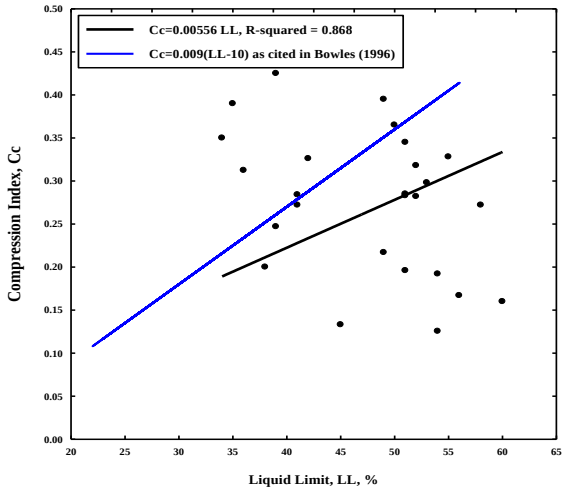

Figure (14) Relation between Compression index and liquid limit.

SUMMARY OF THE RESULT

From all the correlation that connect between physical and mechanical propreties of Ammarah soil, it can be summarized in table (2):

Table (2) Summary of the correlations between physical and mechanical properties of Ammarah soil.

Parameter	Equation	R^2	Equation number	Figure number
|PI	$PI = 0.536 (LL-0.71)$	0.636	1	4
γ_t	$\gamma_t = 30.28 – 21.46\ e_o + 10.17\ e_o^2$	0.811	2	5
e_o	$e_o = 0.025\ \omega_n + 0.078$	0.945	3	6
c_s	$c_s = 0.091\ c_c$	0.97	4	7
c_c	$c_c = 0.24\ LI + 0.21$	0.61	5	8
c_c	$c_c = 0.0092\ \omega_n$	0.946	6	9
c_s	$c_s = 0.00087\ \omega_n$	0.975	7	10
c_c	$c_c = 0.00556\ LL$	0.868	8	14
qu	$qu = 186.3-172.5\ LI + 24.2\ LI^2$	0.53	10	11
qu/SPT	$qu/SPT = 0.186\ PI$	0.872	11	12
qu	$qu = 4.24\ SPT$	0.898	12	13

CONCLISION

The soil of Al-Ammarah city is found to be clayey silt to silty clay with low to high plasticity with:

- For physical properties the equation of (1-3) can be useful and easy to find plasticity index, total unit weight and initial void ratio without using and preliminary test from liquid limit, initial void ratio or natural water content.
- The cost of consolidation test is high in comparison with other tests. So, the equation (4-8)
- it's easy way and power full for estimating the compression index and swelling index.
- Also, the unconfined compressive test is not always available. So, equation (10-12) consider convenient and simple for estimating the compressive strength by knowing plasticity index , liquidity index or number of drops.
- The correlation equation of 4 and equation 8 is considered more convenient, simple and easy for estimating swell index and compressibility index.

LIST OF SYMBOLS

c_c = compressibility index.

c_s = swelling index.

e_o= initial void ratio.

LI= Liquit index.

LL= Liquid limit.

Qu = Unconfined compressive strength.

R^2 = Coefficient of determination

SPT = Standard compressive strength.

γ_t = Total unit weigth.

ω_n = natural water content.

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