Empirical Relationships Between Index Properties and Compression Indices of Clayey Soils in Al-Nasiriya City

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Abstract:

Due to rapid development many projects were adopted in Iraq so need many geotechnical investigations have been done on the soil to know the engineering properties.

In order to reach the aim of this research, potential relationships between compression and recompression indices, initial void ratio, and Plasticity indices were investigated.

All of the tests were conducted on clayey samples which had been prepared under isotropic pressure conditions which are different from those in the field of southern Iraq.

The oedometer test takes a long time to measure the compression of clays. This will lead to a very demanding experimental working program in the laboratory.

It has been found that the calculated values of Cr and Cc were affected by physical properties of the clayey soil, the Cr value ranged from 8.3 to 10 % of Cc value. Hence these correlations of compression index from physical properties will help in sparing time and reducing cost during the preliminary investigation for any construction projects.

Keywords: Soil Investigation, Compression, Void ratio, Plasticity Indices.

الخلاصه

نظرا للتطور الحاصل في العراق و اقامة المشاريع الهندسية يتطلب معرفة معاملات أنضغاطية التربة الطينية بأقصر زمن ممكن لاحتساب الهبوط المتوقع للمنشات المقامة عليها .حيث تجارب الانضغاط لحساب هبوط التربة الطينية تتطلب برنامج من التجارب المختبرية و ذلك يستغرق وقتا طويلا .عمل الباحثون في هذا المجال للحصول على علاقات تجريبية التي من خلالها يمكن اختصار زمن البرنامج المختبري .

للوصول الى هدف البحث يتطلب دراسة العلاقة التجريبية بين معاملات الانضغاط و أعادة الانضغاط من تأثير نسبة الفراغ الاولية ،وكذلك تأثير معاملات اللدونة على قيم معاملات انضغاطية التربة الطينية المختارة في جنوب العراق .

تم تحضير عينات مختلفة من التربة الطينية ولمواقع مختلفة بمواصفات هندسية متباينة مختبريا و تحت تأثير ضغط متجانس و متماثل .

تشير النتائج الى وجود علاقة خطية لقيم الانضغاط وأعادة الانضغاط حيث كانت قيمة Cr تتراوح من 8.3 الى 10 %من قيمة Cc وكذلك تأثرها بقيم نسب الفراغ و معاملات اللدونة لنماذج التربة الطينية .

لذلك من خلال التحقيق الاولي للعلاقة التجريبية بين معاملات أنضغاطية التربة الطينية وخصائصها الهندسية يمكن اختصار الزمن و الكلفة لبرنامج اختبار التربة الطينية .

الكلمات المفتاحية :- استقصاء التربة ، الانضغاطية ، نسبة الفجوات ، مؤشرات المرونة .

Introduction:

In order to design any structure the behavior of the soil underneath must be known under various conditions. The prediction of stability and settlement of structures built up above those soils must be evaluated and studied.

Improvement the knowledge of soil mechanics, the gap between the calculated values of settlement and the settlement experienced throughout the life span of the structure has diminished.

Settlement calculation of each soil stratum can be accomplished by various methods ranging from Terzaghis one dimensional consolidation theory to stress path methods (Al Khafaji, 1999).

There are many factors that affect the compressibility, of clayey soils. Some of the more significant factors are mineralogical properties of the clay, its plasticity, percent of sand and silt, properties of pore water, cementation ,thixotropic, temperature ,loading history, OCR, void ratio and natural water content **(** Al-Omari, 2000 **)** .

In over consolidated clayey soils, the Cr index plays an important role, as well as the Cc index, in calculation of settlement. In many studies, it was found that the Cr index was generally 10-20 % of the Cc index **(**Al Khafaji**,** 1999**).**

If it's assumed that these properties directly affect compressibility, as represented by the compression index, it's therefore expected that the same properties would also influence the Cr index. In literature Cc and Cr indices of clayey soils are separately defined as characteristics of a soil **(**Gunduz zeki, 2002**).**

The plasticity index indicates the moisture range through which a cohesive soil has the properties of a plastic material and it indicates the degree of cohesiveness of the soil, **(** Head, 1984 **).**

In the literature, a number of researchers have been looking for a possible relationship between compression and recompression indices.

(Skempton ,1944) correlated the compression index from the liquid limit based on the type of the soil, so he developed two empirical expressions as follows **(**Hough, 1957; Jumikis ,1962):

Cc=0.007(LL-10)……………………………. (1)

Cc=0.009(LL-10)………………………….... (2)

The first expression was for remolded clay depending on 30 samples chosen in random method and covering different parts of the world and the second expression was for undisturbed clay.

(Hough,1957) presented the following correlation for evaluating the compression index based on the liquid limit for Brazilian clays:

Cc =0.0046 (LL -9) ……………….………. (3)

(Razouk and Nashaat, 1993), developed predictive equation for the compression index on the basis of the in-situ void ratio for Al-Fao clay, as follows:

Cc =0.0351 + 0.1979 e_o ………..…………… (4)

(Khetam ,2002) developed an empirical equation for the compression index basing on in-situ voids ratio for Basra clay:

Cc =0.234 $e_o^{1.5}$ …………………………….. (5)

The behavior of soil differs widely due to the degree of consolidation of the soil.so; the way of description of the state of the soil is by defining the parameter over consolidation ratio.

The main objectives of this research were to study the relationships between Cc and Cr indices, and to investigate the effects of physical properties of clayey soils samples on Cc and Cr in order to reduce the oedometer test duration if and when possible (Razouk, 1993; Skempton, 1999).

Laboratory work:

The clayey soil selected to conduct the tests was taken from Al-Nasiriya city .The samples were extracted from the location of the altered clayey soils, from a depth of approximately 1m from the surface. All the disturbed samples were obtained from the location to perform experimental work in the laboratory.

The laboratory work presented in this paper was done in the geotechnical laboratory at university of technology in Baghdad.

The soil mass is well pulverized and transferred into a 100-ml graduated jar. For high plasticity soils the cone penetrometer method gives more accurate values than that obtained using the Casagrande device (**Head, 1984).**

In order to study the effect of different properties of clayey soils on the mineralogical composition of the clay, X-Ray diffraction tests are performed.

The soil fraction was passing the sieve No. 200 dried and mixed with tap water, in a blender. Water was added gradually until the clayey soil attained a fluid consistency. To reach complete fluid consistency and eliminates air bubbles inside the sample, the clayey soil plus tap water mix was gradually blended for approximately 10 days. Afterwards, the fluid like homogeneous mix was placed in a thick self standing membrane inside the triaxial cell.

The experimental part was for remolded clay depending on 45 samples chosen in random method and covering different parts of the regions in Al- Nasiriya city ,divided in three groups (A ,B and C) .

The grain size distribution of the soils used is shown in **Figure, (1)**. Test is carried out according to **(ASTM D 421-72 and D 422-72)**. The specific gravity of soils is determined in accordance to **(BS 1377:1975, test No.6)** using density bottle of 50-ml capacity.

The Atterberg limits are determined in accordance with liquid limit using Cone penetrometer method **[BS 1377:1975, Test 2(A)].**

A series of tests were carried out to investigate the relationship between the consistency of clayey soil described by its plasticity index and the compression indices. Afterwards, the samples were consolidated at varying cell pressure in accordance with a preplanned test program until the pore water pressures were diminished.

Oedometer tests were carried out to investigate the compressibility behavior of clayey soils which have the same origin and are consolidated under isotropic condition at different pressures.

Result and Discussion:

The compression index could be correlated simply with soil indices, such as in situ void ratio, liquid limit water content etc. to obtain a good empirical estimation for the compression index to predict the settlement of structures on the normally consolidated clay .

Any disturbance induced to the sample during the stages of extraction, handling and testing creates enormous changes in its behavior. That reflects errors in estimating the true value of the data reported in the site investigation reports.

Physical properties of the three groups of clayey samples soils used are listed in **table (1)**.

The grain size distribution curves, as obtained from wet sieve and hydrometer analysis are presented in **figure (1).**

Three correlations are obtained by relating the plasticity indices and the compression index with the clayey soil property to evaluate its compressibility for these samples, **Figures, (6, 7 and 8)**. The best relationship is obtained by relating the compression index with in -situ void ratio, which indicates a good estimation to evaluate the compressibility of the normally consolidated clay.

The relations between the compression and recompression are slightly scattered it may be possible to say that there are linear relationships, **Figure (6).**

The plots between the values of void ratio and Cc are denoted an almost linear relationship , as shown in **figure (7).** This increase is predictable since compression index is usually proportional to void ratio. The high value of void ratio, the higher Cc is indicating a highly compressible soil.

Recompression index Cr is slightly influenced by void ratio but Cc mostly affected by void ratio as seen in **figures (3, 4 and 5).**

The suitable fitting equations for the presented data are shown in **table (2),** Comparisons between the compression indices and physical properties of clayey soils represented by correlations equations for clayey soil samples (A, B, and C). These values are in agreement with those reported in the literature.

The difference in the variations of these values may be attributed to several reasons such as the difference in soil layers, the level of water content, the percent of clay and other factors.

In order to finalize and obtain more accurate correlation among the parameters, the number and types of clayey samples should be increased. Therefore, this study can be considered as a preliminary investigation for a prototype high plasticity clayey soil. also confirms that there is more than one parameter affecting compression and recompression values.

Conclusion:

- This study is to take full advantage of the existing information of site soils investigation which obtained from the properties of clayey soils from different region in southern of Iraq.
- A linear relationship between Cc and Cr indices was noted.
- Observed clearly, that the relationship between Cc and void ratio were proportional.
- Suitable fitting equations were presented in table (2), depend on many parameters, and therefore were evaluated based on the local conditions.
- Three correlations are obtained by relating the plasticity indices and the compression index with the clayey soil property to evaluate its compressibility. From the results, it was found that the Cr value was ranged from 5.8 to 10 % of the Cc value
- This testing process time would be reduced to half the normal testing time. Then, the laboratory work would also decrease.

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Table (1) Physical properties of clayey soil s samples

Properties of samples	Sample, A	Sample,B	Sampl,C
Specific Gravity,Gs	2.71	2.72	2.74
Max.Dry Unit Weight,(kN/m^3)	16.5	16	15.6
Optimum Moisture Content (%)	18.3	18	16.2
Liquid Limit, L.L (%)	48.4	50.1	51.3
Plastic Limit, P.L (%)	23.2	25.7	27.1
Plasticity Index, P.I (%)	25.2	24.4	24.2
Sand, (%)	10	5	4
Silt, (%)	16	14	11
Clay, (%)	74	81	85

Table (2) Equations of compression index and physical properties of clayey soil

Correlation Expression	Sample, A	Sample, B	Sample, C
Compression index and Liquid Limit	Cc=0.002L.L +0.139	Cc=0.0028 L.L +0.149	Cc=0.003L.L+0.237
Compression index and Recompression	Cc= 15.44Cr-.0634	Cc= 15.68Cr-0.008	Cc= 16.74Cr-0.007
Compression index and Void Ratio	Cc= 0.0978+ 0.188 eo	Cc= 0.26+0.1237 eo	Cc= 0.293+0.138 eo

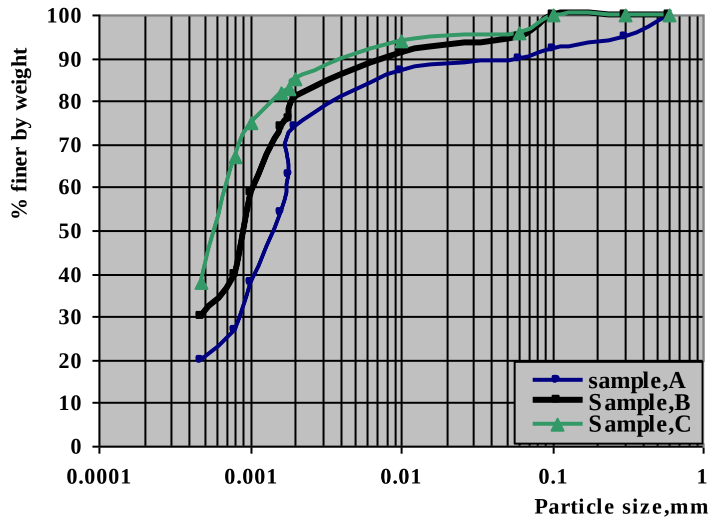

Figure (1). Grain size distribution of Clayey samples.

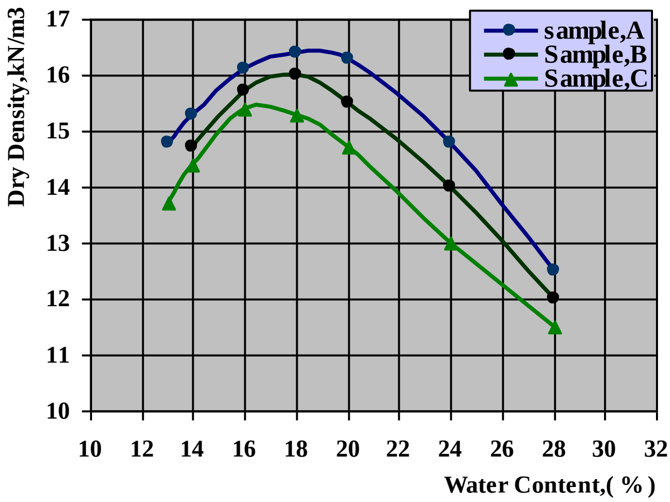

Figure (2) . Proctor Compaction curves for Clayey samples.

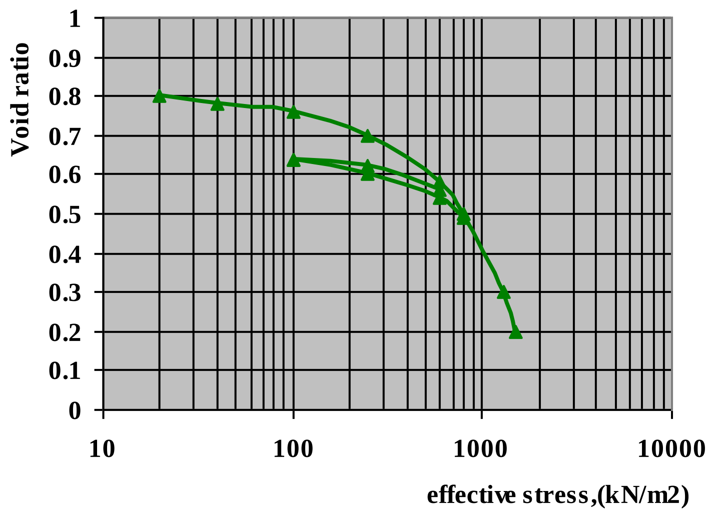

Figure (3) Compression curve of Sample,(C)

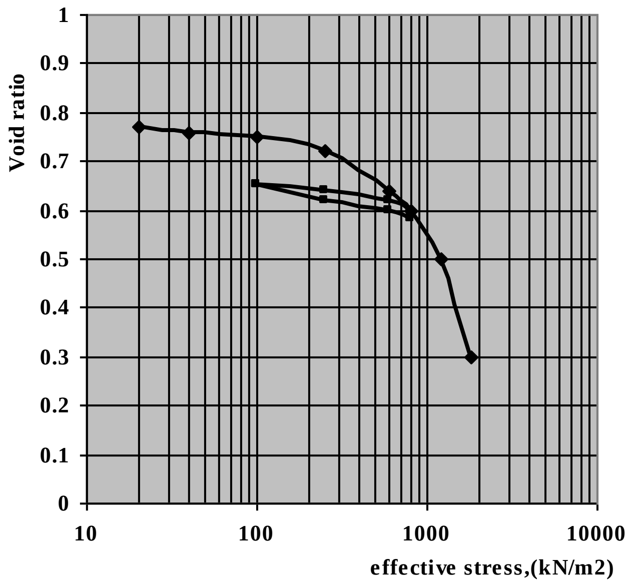

Figure (4)Compression curve of Sample(B)

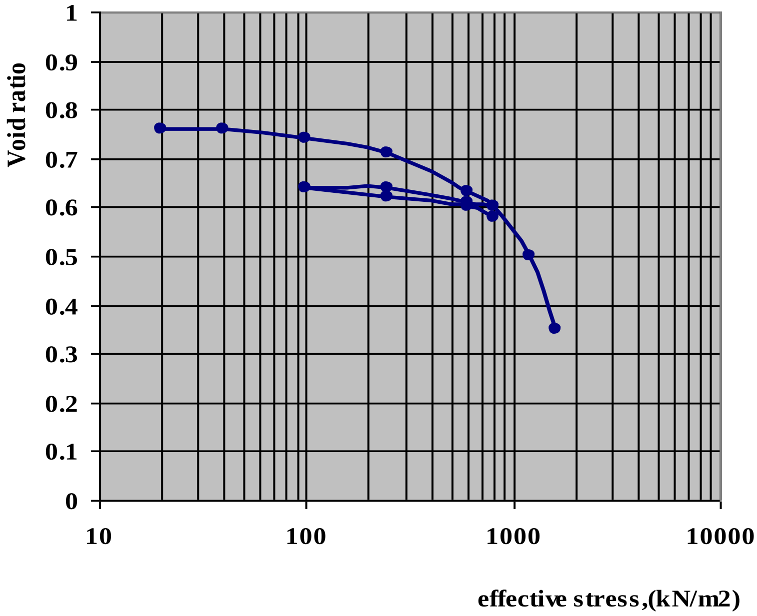

Figure (5) Compression curve of Sample (A)

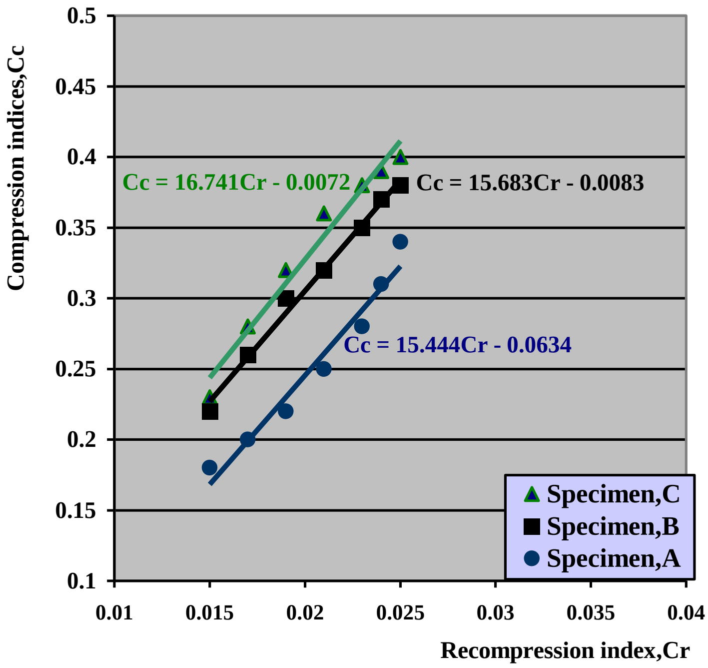

figure (6),Relationships between compression and recompression indices

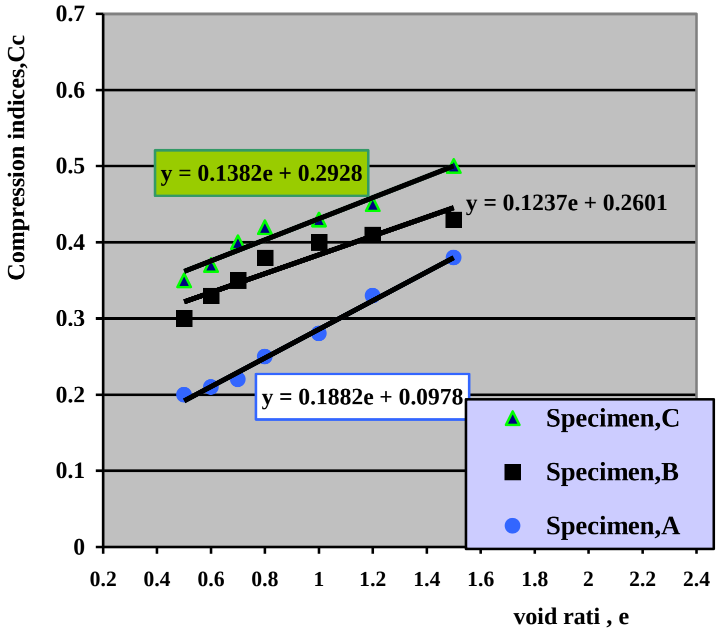

figure (7),Relationships between compression and void ratio