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EFFECT OF ORGANIC WASTE ON GEOTECHNICAL PROPERTIES OF SOFT CLAY

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Abstract: Artificial soils were prepared by mixing kaolinite with different percentage of organic material (animals waste) represented by 5, 10, 15 and 20% of soil dry weight. Series of Standard tests were conducted to determine the physical and mechanical properties of the soil such as, Grain size distribution of soils, Atterberg limits, soil compaction, vane shear test and oedometer test. The test was conducted on the soil with and without organic content. The results revealed that, the organic waste have a significant effect on the physical properties of soil such as, liquid limit, plastic limit and plasticity index. In addition the organic waste have significant effect on the compression index and on the coefficient of secondary compression. The analyses were performed using two cases: The first case is using constant value of undrained shear strength (this achieved by adding different water content to the artificial soils) and the second case is using a soils at constant water content and constant dry unit weight.

Keywords: *Kaolinite, organic waste, Atterberg limits , Dry unit weight, Optimum Moisture content , Compression index, Rebound index.*

الخلاصة: تم تحضير تربة مصنعة من خلط الطين الحر (الكاولنايت) مع نسب مختلفة من مخلفات حيوانية وكانت النسب تمثل 5 و 10و 15 و20% من وزن التربة الجافة . لقد تم اجراء عدد من الفحوصات القياسية على التربة لدراسة الخواص الفيزياوية والميكانكية والمتمثلة ب التحليل الحبيبي للترب ، حدود اتربرك ، رص التربة ، فحص القص بالمروحة و فحص الانضمام . لقد نفذت التجارب على الترب الطبيعية والترب المخلوطة مع المادة العضوية. لقد أظهرت النتائج بان المادة العضوية لها تاثير ملحوظ على الخواص الفيزيائية وموءشر الانضغاط الانضغاط مثل حد السيولة واللدونة وموءشر اللدونة. بالاضافة الى ان المادة العضوية لها تاثير ملحوظ على موءشر الثانوى. لقد تم اجراء التجارب بحالتين :الحالة الاولى بتثبيت قيمة القص غير المبزول ولقد تمكن من تحقيق هذا با استخدام نسب مختلفة من المحتوى المائى و الحالة الثانية بتثبيت المحتوى المائي والكثافة الجافة .

1. Introduction

In recent years more and more constructions like buildings and embankments have been built on soft clay which content significant percentage of organic materials especially in countries with increasing in population density. Clayey soils with organic content are extremely complex materials. The organic contents have the greatest

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influence on the physical and mechanical properties of the soil, which is classified as low in permeability, low in shear strength, and high in compressibility. The organic particle has the ability to absorb water and become sponge- like and soft (Franklin et al.)[1]. Many researchers focusing to study the effect of the organic content on the behavior of soils.

Song et al. [2] concluded that as the organic content increases, the compaction curve tends to be situated below and to the right.

Thiyyakkandi and Annex [3] studied the properties of Kuttand organic clay from India. Because of the effect of ignition on some of the organic matter by oven drying, the organic content was varied artificially by adding urea (CH_4N_2O). The results of this study indicate that the plasticity and compressibility characteristics of the clay were increase with the increasing of the organic content. The shear strength of the clay greatly decreases with the increasing in the organic content. However negligible variation in the maximum dry density was observed with the increasing in organic content.

Adjumo [4] investigated the effect of organic content on the compaction and consolidation characteristics of Lagos clay from Nigeria by adding urea crystals. The plasticity and compressibility of the clay increase with the increasing in the organic content while the shear strength reduces and with slight variation in the maximum dry density was observed.

Al-Adili, A.and Al-Sudany [5] evaluated the effect of organic content on Dialya clay from Iraq by adding organic material consist of animal disposals and plant pieces (leaves). The results revealed that, the stiffness of clayey soil decreases as the organic content increases while the plasticity and liquidity increased.

Sadiq [6] used the kaolin clay and mixed it with different percentages of organic material (reed). The results revealed that, the plasticity and compressibility characteristics increase as the organic content increase and the cohesion and angle of internal friction increase too.

There are many other researchers who studied in this subject such as Habib[7], Puppala et al.[8] ,Abd Al-Nafia [9]and Ali[10].

2 .Experimental work

The kaolin clay was mixed with an organic matter (animal wastes) at different percentages (0, 5, 10, 15, 20)% by dry weight of soil . The mixed soil was saturated and kept in plastic bags for six months at warm condition to achieve decomposition of the organic material.

Grain size distribution ,X-Ray Powder Diffraction (XRD) ,specific gravity , Liquid limit , plastic limit, compaction test, one dimensional consolidation test ,vane shear test ,direct shear test were conducted to the soil samples to investigate the properties of the soil samples. Table (1) shows the standard of these tests.

Table 1. Standards of laboratory tests

Test	Standards
Grain size distribution	ASTM D422
Specific gravity	ASTM D 854
Liquid limit, Plastic limit	ASTM D 4318
Compaction test	ASTM D698-78
One dimensional consolidation test	ASTM D 2435-80
Vane shear test	ASTM D 2573
Direct shear test	ASTM D3080-72

3 . Results

3.1. Liquid and Plastic limits

The results of the plastic and liquid limits and plasticity index tests are shown in Figures (1) and (2). The results revealed that, the liquid limit, plastic limit and plasticity index increase linearly with the increasing in the organic contents .These results are attributed to the high capacity of organic materials to absorption water. These results are agreed with Thiyyakkandi and Annex [3].

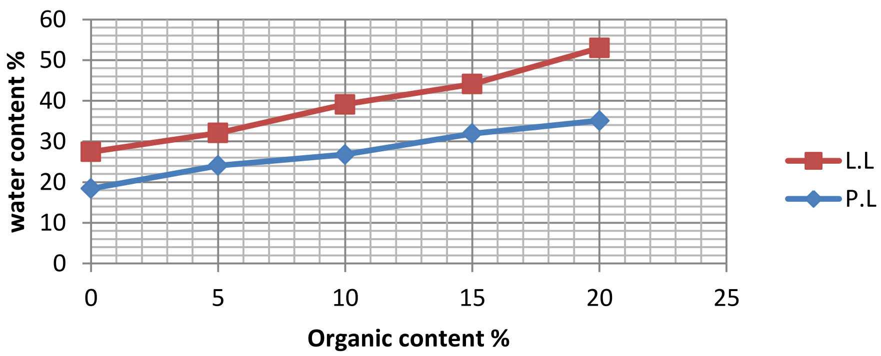

Figure 1. Variation of Liquid and Plastic limits with the organic content.

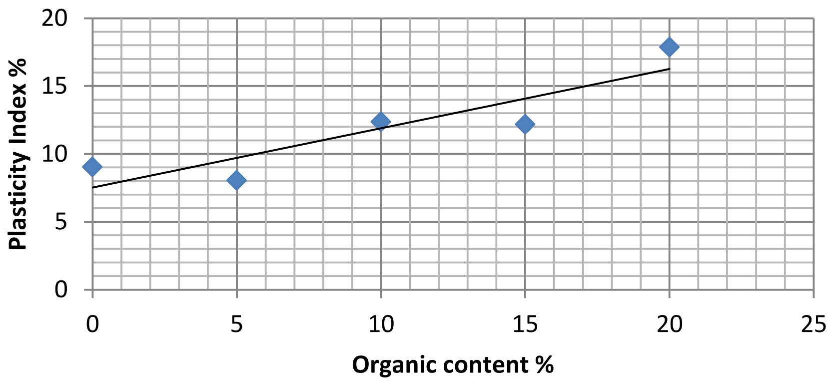

Figure 2. Variation of Plasticity Index with the organic content.

3.2. Specific Gravity

It can be seen from Figure (3) that the specific gravity decreases as the organic content increases. This is due to the reduction of the unit weight of the solids in the soil mixture. These results are agreed with Al-Adili, A.and Al-Sudany [5].

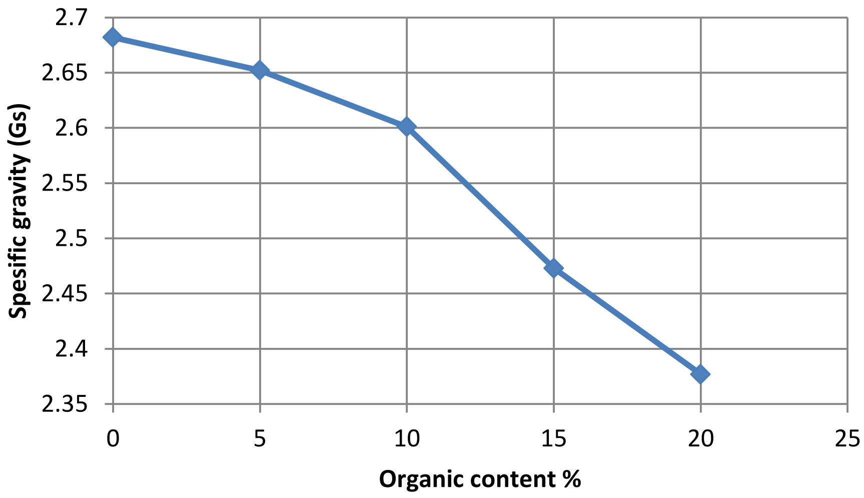

Figure 3. Variation of specific gravity with the organic content.

3.3. Compaction Test

The relationship between the dry unit weight of soil and water content is shown in Figure (4). The results indicated that, as the organic content increases, the maximum dry unit weight decreases while the optimum moisture content increases. The reduction in the dry unit weight as the increase in the organic content is due to the increase in void ratio and decrease in specific gravity, while the increase of water content is due to high capacity of organic material to absorb water.

Figures (5) and (6) show the variation of the dry unit weight and the optimum water content with percentage of organic content which ranged from 5% to 20%. The results show that, the maximum dry unit weight decreases as the organic content increases while the optimum moisture content increases with the increase in organic content.

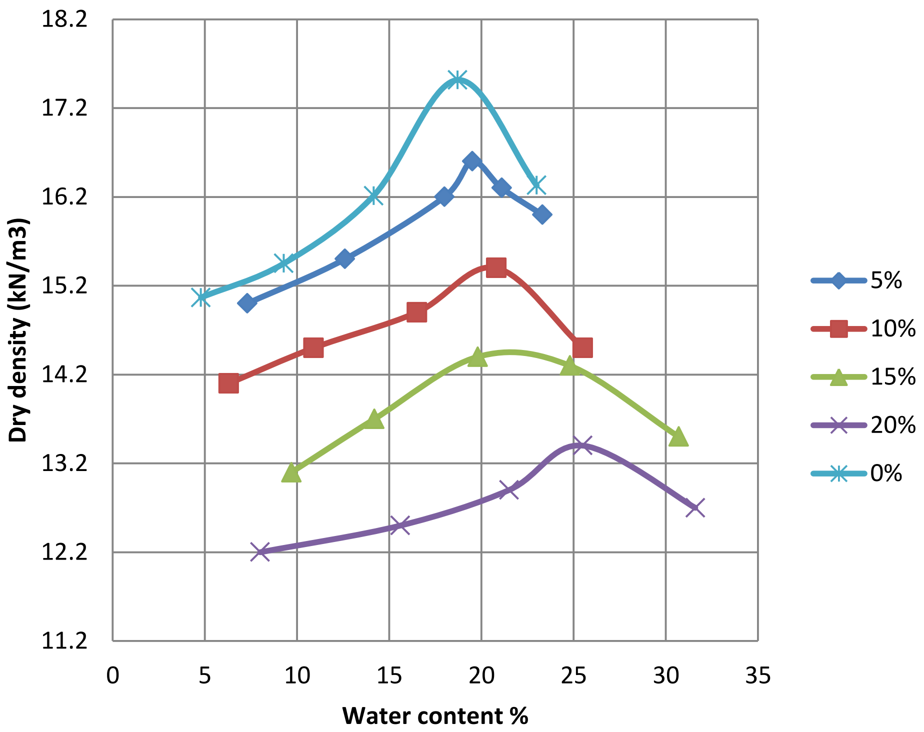

Figure 4. Dry unit weight –water content relationship of soil with different percentage of organic content.

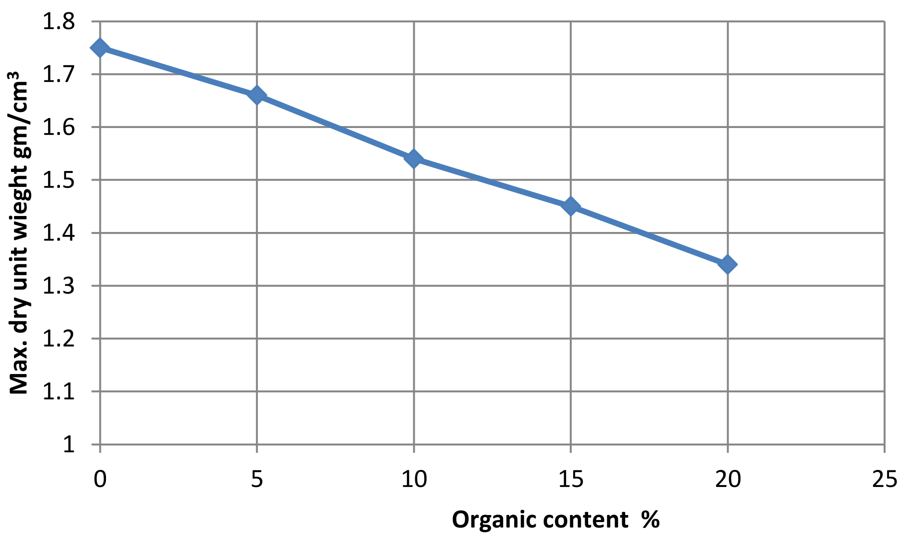

Figure 5. Variation of maximum dry unit weight with the organic content.

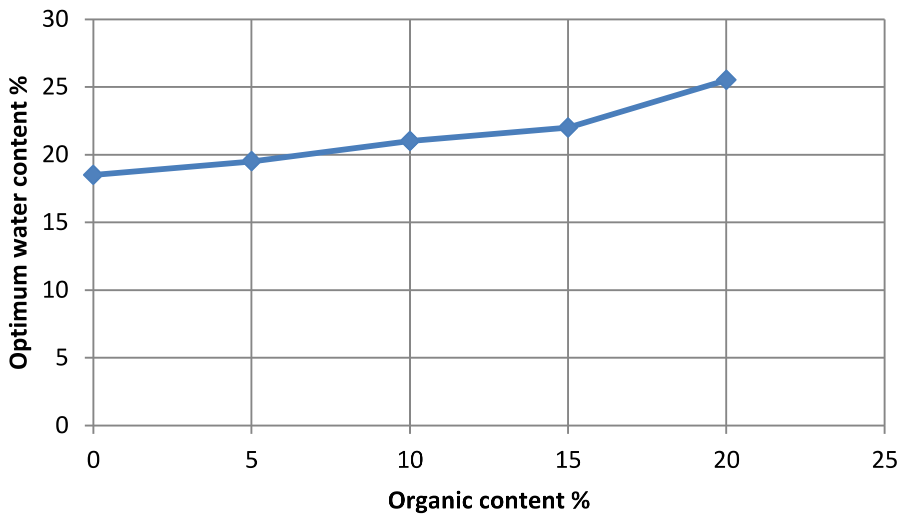

Figure 6. Variation of the optimum water content with the organic content

3.4. Undrained shear strength -Water content relationship

The undrained shear strength for the soil samples is determined by using Vane shear test. Figure (7) shows the relation between the undrained shear strength and water content for the soil samples with different organic content. These tests were performed in order to choose the value of water content which gives undrained shear strength equal to 23 kPa. The results indicated that as the water content increases, the undrained shear strength decreases. This is due to the fact that the strength of the soil is highly affected by water content and since the water content is highly increased with the increasing in the organic content.

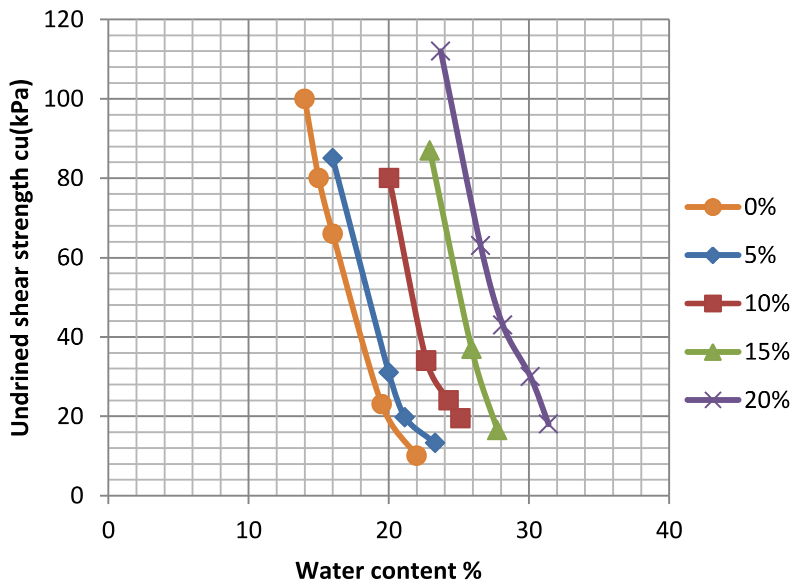

Figure 7. Undrained shear strength (c_u)–water content curve for soil sample

3.5. One Dimensional Consolidation Test

For prepared soil samples two cases were studied in order to evaluate the effect of organic content on the properties of the soil .These cases are:

3.5.1. Constant undrained shear strength

The consolidation test is conducted on the artificial prepared soil samples at the same undrained shear strength value (c_u = 23kPa) which is chosen from Figure (7). These samples have different water contents and dry unit weights. Figure (8) shows the results of these testes.

3.5.2 Constant water content and constant dry density

Consolidation test is conducted on the soil samples at the same water content of (30%), and same density of (12.9 kN/m^3). The results of these testes are shown in Figure (9)

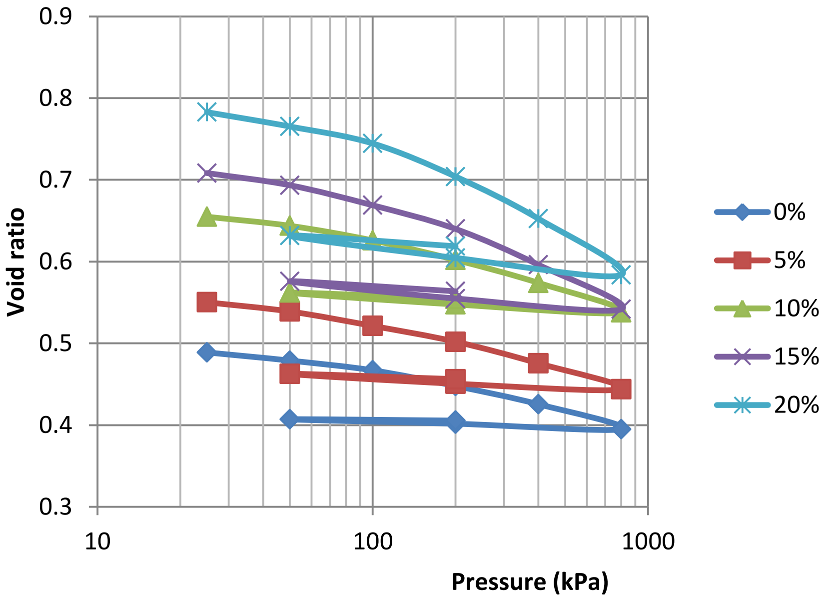

Figure 8. Void ratio – effective vertical stress relationship of artificial prepared soil sample at constant c_u (c_u = 23 kPa)

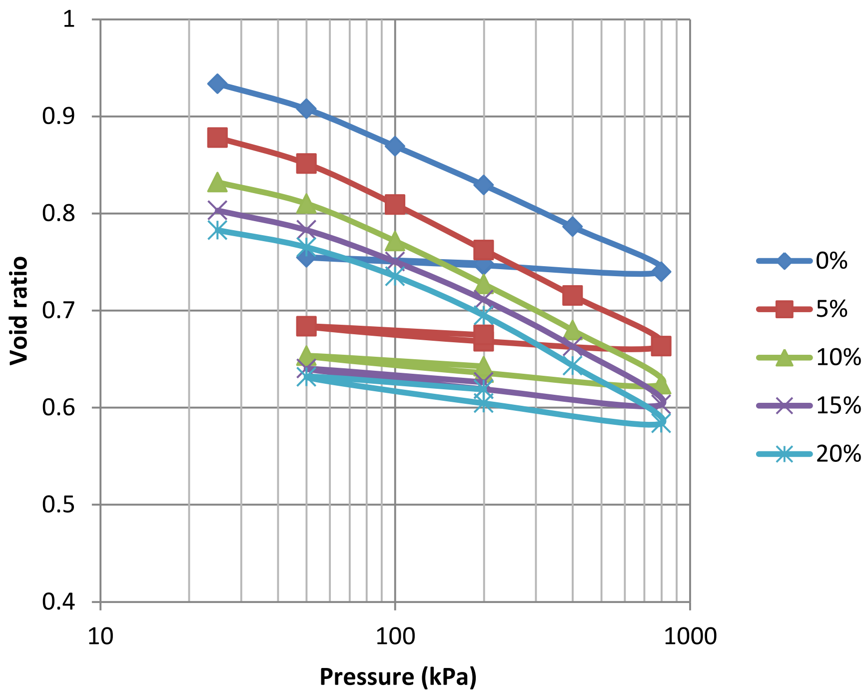

Figure 9. Void ratio – effective vertical stress relationship of artificial prepared soil sample at (w=30% , γ =12.9kN/m^3)

3.6. Effect of organic content on consolidation properties

3.6.1. Effect of organic content on the rebound index C_r

The effect of the organic content on the rebound index of the soil samples was shown in Figure (10) for two cases (constant undrained shear strength, constant water content and dry density). The rebound index was increased in case of constant undrained shear strength (c_u =23kPa) as the organic content increases but it was decreased in case of constant water content and density (w=30% , γ =12.9gm/cm^3) as the organic content increases.

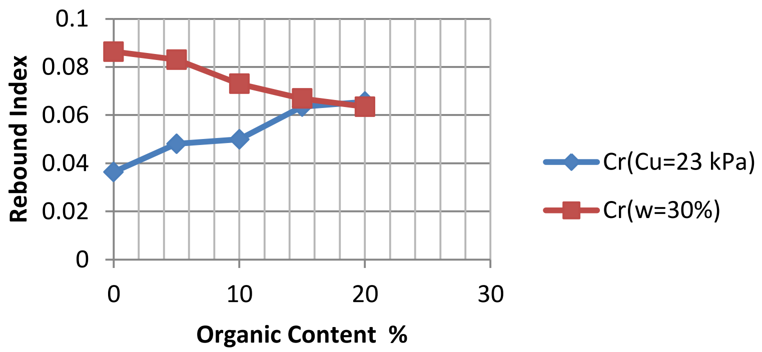

Figure 10. Organic content with rebound index

3.6.2. Effect of organic content on compression index C_c

Figure (11) shows the effect of the organic content on compression index for two cases (constant undrained shear strength, constant water content and dry density). The compression index was increased in these two cases as the organic content increases.

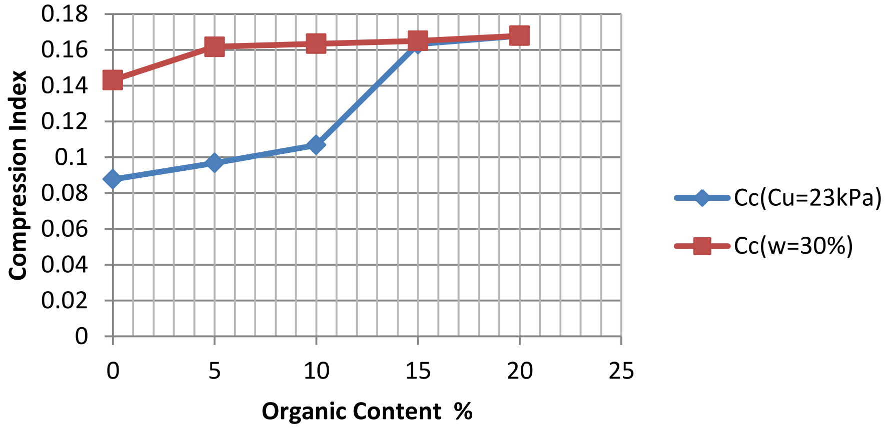

Figure 11. Organic content with compression index.

3.6.3. Effect of organic content on the coefficient of consolidation C_v

Figure (12) shows the relation between the organic content and the coefficient of consolidation for two different effective vertical stresses and different conditions. Log - time method used to determine the coefficient of consolidation.

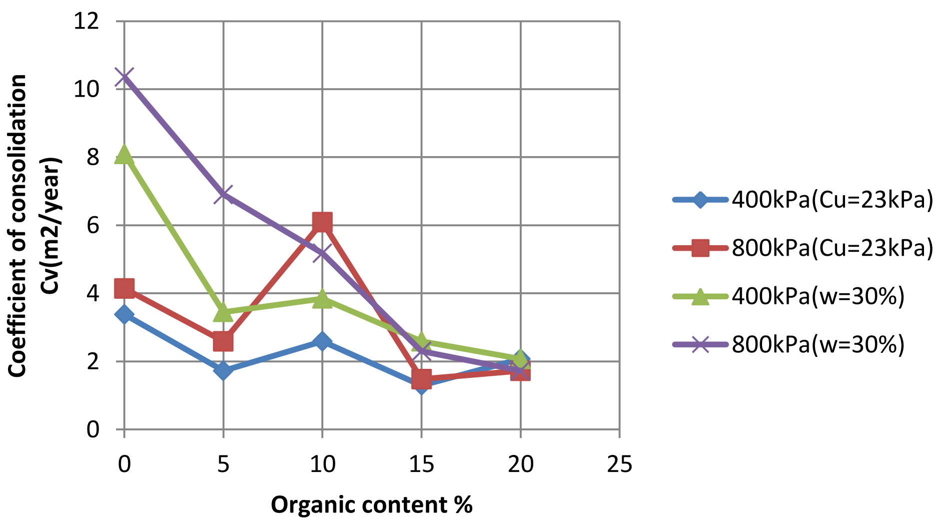

Figure 12. Variation of the Organic content with the coefficient of consolidation.

3.6.4. Effect of organic content on coefficient of secondary compression C_α

The coefficient of secondary compression was increased in the two cases (constant undrained shear strength, constant water content and dry density) and it is increased as the vertical effective stress increased. Figure (13) show these results.

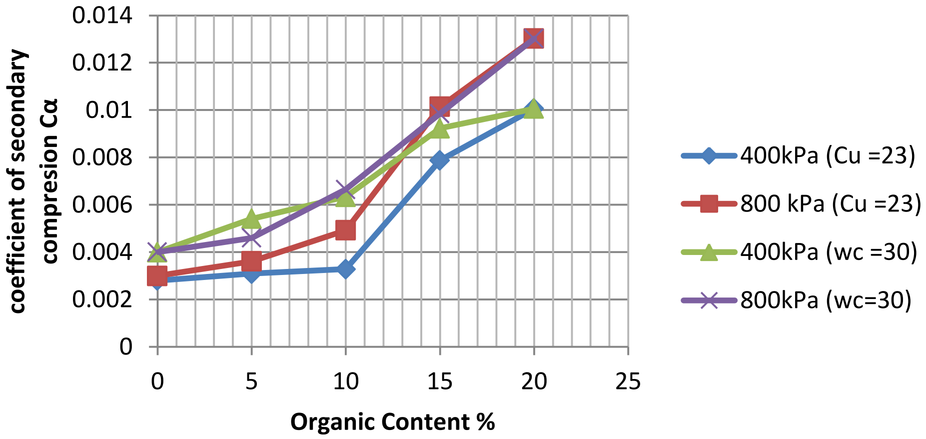

Figure 13. Organic content with coefficient of secondary compression.

3.7. Direct shear test

The angle of internal friction (φ) and the cohesion (c) of the artificial prepared soil samples are investigated in this test. The test was conduct under three selected normal stresses applied to the soil samples that have the same undrained compressive strength (Cu =23 kPa). Figures (14) ,(15) show the variation of the angle of internal friction and the cohesion with organic content respectively. Both the cohesion and the angle of internal friction are little increase with the increasing of organic content . These results were compatible with Sadiq [6] results.

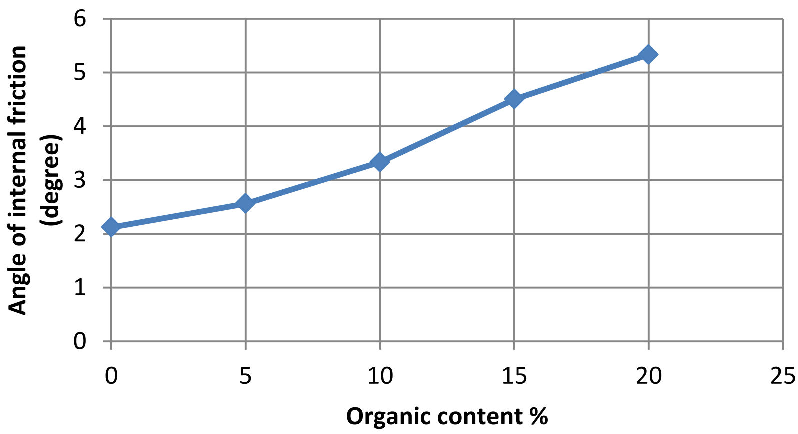

Figure 14.Variation of the Organic content with the angle of internal friction.

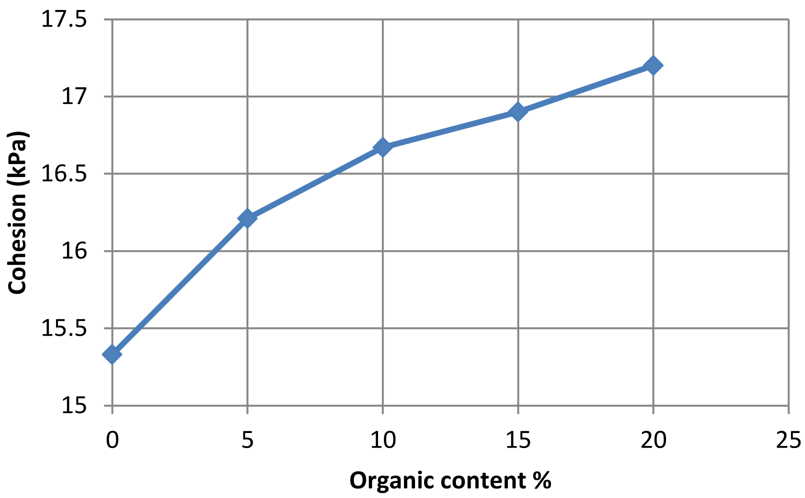

Figure 15.Variationof the organic content with the cohesion.

3.8. Mineralogical Analysis: X- Ray Powder Diffraction (XRD)

The X- Ray Powder Diffraction (XRD) analysis is performed to investigate qualitatively the composition of the clay mineralogy in the soil samples. The main purpose of this test is to identify the clay minerals such as kaolinite, illite , montmorolonite etc.These minerals may influence the behavior and properties of the clay materials. The results of this test are shown in Figures (16) to (20). According to the results of the XRD test the organic content dose not affected on the mineral composition of the soil.

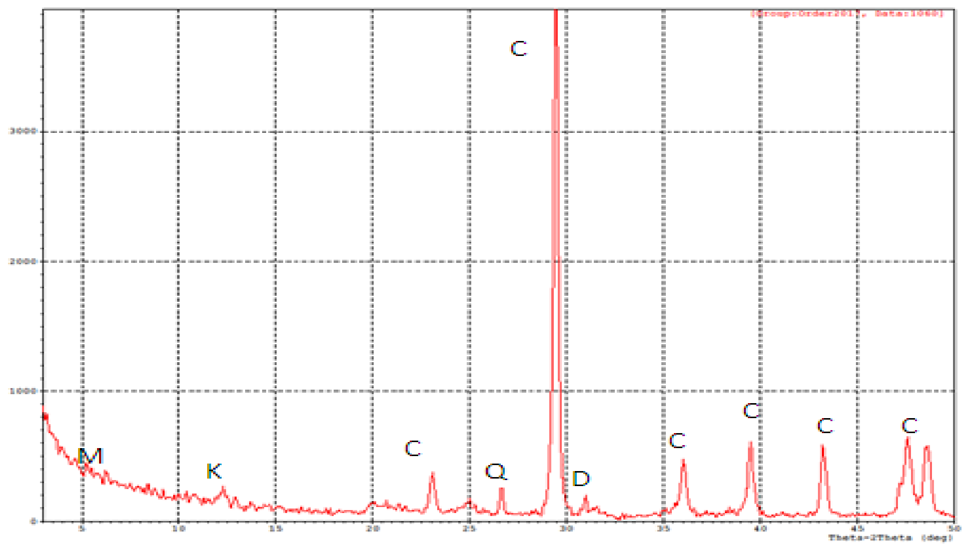

Figure 16. XRD for kaolin with 0% organic content.

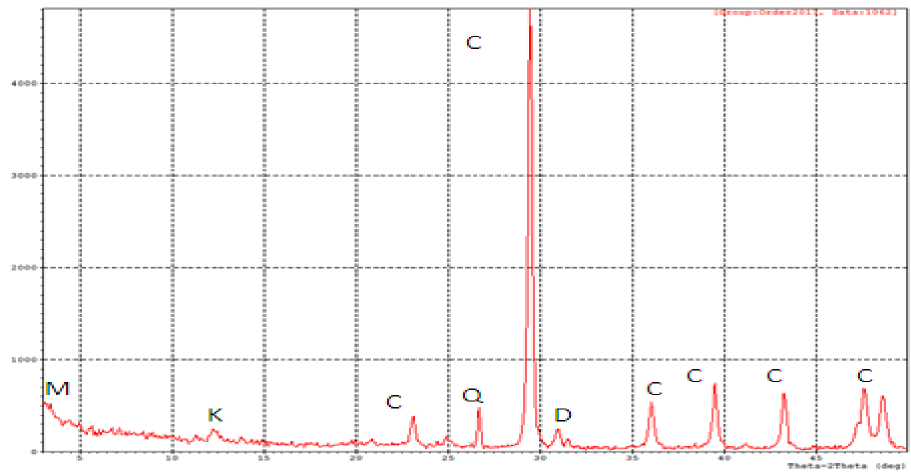

Figure 17. XRD for kaolin with 5% organic content.

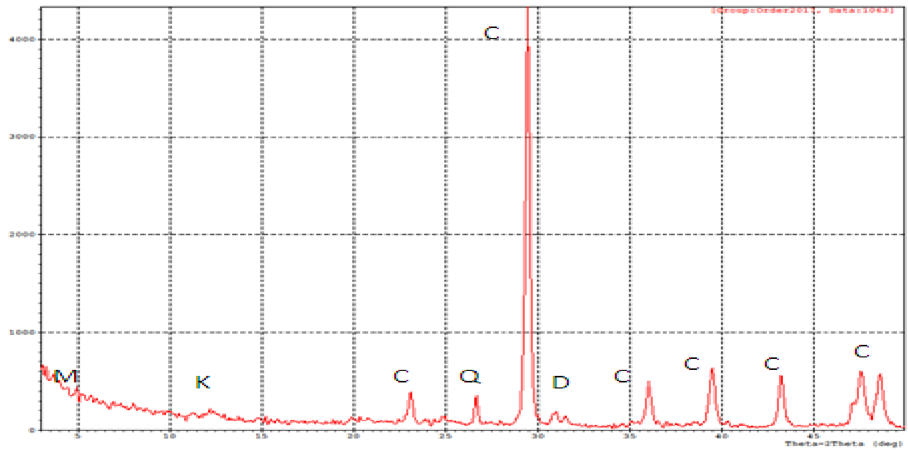

Figure 18. XRD for kaolin with 10% organic content.

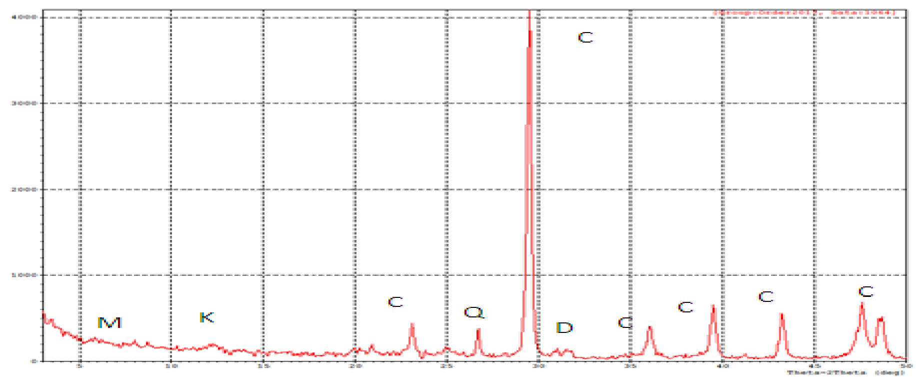

Figure 19. XRD for kaolin with 15% organic content.

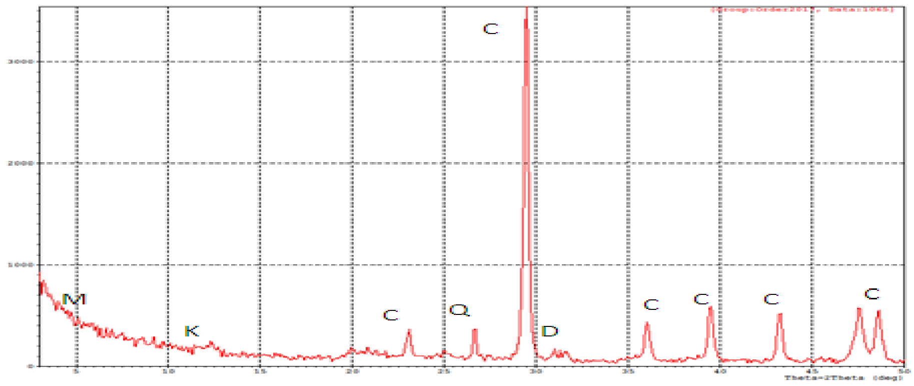

Figure 20. XRD for kaolin with 20% organic content.

Where:

M Montmoroillonite

K Kaolinite

C Calcite

Q Quartz

D Dolomite

F Feldspar

P Polygorskite

4. Conclusions

The effect of organic content on clayey soil is investigated in this study. The results indicated that when organic content increases:

-Liquid limit increased by (18, 44, 62, 96) % for 5, 10, 15, 20% organic content, respectively.

- Plastic limit increased by (20, 40, 70, 94) % for 5, 10, 15, 20% organic content, respectively.

-Specific gravity decreased from 2.657 for 0% organic content to 2.37 for 20% organic content.

-Optimum moisture content increased by (11, 23, 29, 52)% for 5, 10, 15, 20% organic content, respectively.

- The dry density decreased by (4, 11, 16, 24)% for 5, 10, 15, 20% organic content, respectively.

- Void ratio increases in case of constant undrained shear strength and decreases in case of constant water content and dry unit weight.

-Rebound index decreases in case of constant undrained shear strength and increases in case of constant water content and dry unit weight.

- Compression Index increases in both cases, constant undrained shear strength and constant water content and dry unit weight.

- Coefficient of consolidation decreases in both cases, constant undrained shear strength and constant water content and dry unit weight at different effective stresses.

- Coefficient of secondary compression increases in both cases, constant undrained shear strength and constant water content and dry unit weight at different effective stresses.

-The cohesion of the soil increased from 15.3 for 0% organic content to 17.2 for 20 % organic content.

- The angle of internal friction increased from 2.1 for 0% organic content to 5.2for 20% organic content.

-The mineral composition of the soil dose not affected by organic material.

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