IRAQI Academic Scientific Journals

Tikrit Journal of Engineering Sciences (2021) 28 (2): 80-92

College of Engineering

ISSN: 1813-162X (Print) ; 2312-7589 (Online)

Tikrit Journal of Engineering Sciences

available online at: http://www.tj-es.com

TJES Tikrit Journal of Engineering Sciences

Muhauwiss FM, Hassoun SS. Wetting And Drying Cycles Effect On Durability Of Gypsum Solis Treatrd With Calcium Chloride Or Cement Additives. *Tikrit Journal of Engineering Sciences* 2021; **28**(2): 80- 92.

WETTING AND DRYING CYCLES EFFECT ON DURABILITY OF GYPSUM SOILS TREATED WITH CALCIUM CHLORIDE OR CEMENT ADDITIVES

Farouk M. Muhauwiss*

Sura Saad Hassoun

Department of Civil Engineering /College of Engineering / Tikrit University

Keywords:

Gypseous soil, cement, calcium chloride, durability.

ARTICLE INFO

Article history:

Received	12 Dec. 2019
Accepted	20 May. 2021
Available online	07 Apr. 2021

ABSTRACT

The study consists of two stages: the first one is to improve the gypsum soil with cement or calcium chloride and the second stage is to expose these soil specimens to series of wetting and drying cycles .Three soil specimens were taken and marked as (A,B and C) with gypsum content (47, 32 and 23)% respectively .The results show that cement additive increases the cohesion of soil specimens to 50% and collapse potential decreases with 65% and soil specimens improved with calcium chloride increase the cohesion up to more than 70% and collapse potential decreased about 70%. In the first cycle for wetting and drying cycles for soil specimens improved with cement the cohesion decreases about 25% and stays with the same ratio of the decreasing along the other cycle up to twelfth cycle. Collapse potential remains with the same value and is not affected by cycling of wetting and drying. In the first cycle for soil specimens treated with calcium chloride there is no effect in the first cycle whereas in the fourth cycle the cohesion increased by 60% and in the eighth cycle the cohesion decreased 8% and remains stable until the twelfth cycle. Collapse potential increases from one cycle to another by (30-50) % for all soil specimens.

DOI: http://doi.org/10.25130/tjes.28.2.07

تاثير دورات الترطيب والتجفيف على التربة الجبسية المعالجة بالمضافات الكيميائية او الاسمنتية

فاروق مجيد مهوس قسم الهندسة المدنية/ كلية هندسة / جامعة تكريت

سرى سعد حسون قسم الهندسة المدنية/ كلية هندسة / جامعة تكريت

الخلاصة

تضمنت هذه الدراسة مرحلتين, المرحلة الاولى معالجة التربة الجبسية بالاسمنت او كلوريد الكالسيوم والمرحلة الثانية هي معرفة ديمومة التربة المعالجة بعد تعرضها لدورات ترطيب وتجفيف .استخدمت ثلاث ترب جبسية مختلفة في محتوى الجبس النوع (A) محتوى الجبس 47% والنوع (B) محتوى الجبس 32% والنوع (C) محتوى الجبس 23% ، اظهرت النتائج ان اضافة الاسمنت الى التربة الجبسية تزيد من تماسك التربة بنسبة 50% في حين معامل الانهيارية تناقص بنسبة 65% اما عند اضافة كلوريد الكالسيوم فيزداد تماسك التربة لاكثر من 70% ويقل معامل الانهيارية لأكثر من 70% . في الدورة الاولى من دورات الترطيب والتجفيف للتربة المعالجة بالاسمنت تناقص التماسك في التربة بنسبة 25% وبقت تقريبا نفس القيمة من التناقص على طول الدورات حتى الدورة الثانية عشرة بينما معامل الانهيارية لم يتاثر بدورات الترطيب والتجفيف . في الدورة الاولى للتربة المعالجة بكلوريد الكالسيوم كان التاثير على قوة التماسك قليل جدا ثم ازداد

* *Corresponding author: E-mail:* dr.faroukmajeed@tu.edu.iq , Department of Civil Engineering /College of Engineering / Tikrit University

بنسبة 60% في الدورة الرابعة ورجع وتناقص بنسبة 8% في الدورة الثامنة وبقت تقريبا نفس قيمة التماسك في الدورة الثانية عشرة , اما معامل الانهيارية فازداد من دورة الى اخرى بنسبة (30-50)% لكل عينات التربة المستخدمة

1. INTRODUCTION

The gypsum soil is known to have high strength when dry but it is subject to reduction in strength when its water content increases therefore, the gypsum soil is classified as a collapsible soil. Behavior of gypsum soil depends on gypsum content which is one of the most common metals found in gypsum soils and it varies from low less than 5% to more than 50% (1). The soil must be improved before constructing any building on it, some methods of treatment are not workable and the others are expansive (2) and the improvement depends on the type of structures and the type of defects encountered (3,4). Cement additive gives a good improvement rate after mixing with the soil and calcium chloride was also used to improve the properties of weak soil.

Durability is no less important than improving the soil with additives due to the impact of soil properties on weather changes during the seasons, therefore, it must study the durability and its effect on the treated soils before constructing any building on it. The soft grains are affected more than coarse grains from the water flows or they evaporate because soft grains need a longer period to evaporate water (5). For stable soils with cement, there are two standard procedures for durability tests. ASTM D559-57 standard test method for wetting and drying, and ASTM D560-57 standard test method for freezing and thawing (6). Many researchers studied the treatment and durability of gypseous soil such as (Alhuluw-2008) (7) who studied the compressibility of gypseous soil by adding cement or calcium chloride, three ratios of cement are used (1,2 and 3)% or four ratios of calcium chloride (2,3,5 and 6)%. The effect of adding cement to soil is that the amount of collapse decreases and the effect of adding calcium chloride is that there amount of collapse decreased by (40%), Al-Neami (2010)(8) illustrates improvement of gypseous soil by adding clinker material. Clinker material was added by ratios (2, 4 and 6%). It was found that the ratio of 4% led to the improvement of collapse 73% and decreased compression about (29-41) %. Obaydi et.al (2010) (9) argue that improving the properties of gypsum soil and carrying out cycles of wetting and drying after treatment. The soil used was gypsum content 23% and the compound improvement was made from the (waste lime+ cement) in different percentages (4% + 8%) , (6% + 8%) and (8% + 8%) and using the cement material alone with different percentages (4,8,12 and 16)% and using waste lime material alone with different percentages (4, 6 and 8) %. The results showed that soil stabilized with compound additives (waste lime / cement) is the best treatment soil against durability and the soils stabilized with lime waste alone fail with wetting and drying cycles. AL-Kiki (2011) (6) considers improvement of the clayey soil with (5%) lime and then carried out wetting and drying cycles. Thawing and slaking, results showed in durability the volume and soil strength and weight loss for samples exposed to three environmental conditions more changes form samples exposed to the two conditions only and that the first condition of the cycle has more effect on the soil for models exposed to the two conditions only and the second condition has more effect or samples exposed to the three conditions. In the above researches there are many treatments for gypsum soils with different treatment materials and in different percentages and there are many researches which studied the effect of wetting and drying cycles on clay and gypsum soils without treatment. In this research we study the effect of wetting and drying cycles on gypsum soils treated with cement or calcium chloride and made comparison with the results to select the best material to resist the effect of wetting and drying cycles.

2. EXPERIMENTAL PROGRAM

2.1. Apparatus and Procedures

2.1.1 Direct Shear Test

The test is conducted according to the (ASTM D-3080) at field unit weight and field moisture content. This experiment was carried out on the specimens for natural soil and after treatment with calcium chloride or cement and after (1, 4, 8 and 12th) cycles for wetting and drying cycles.

2.1.2 Unconfined Compression Test

The unconfined compression test is carried out according to (ASTM D2166-85) using a constant strain compression machine with a rate of loading of (0.5 mm/min). Test was used on disturbed (untreated and treated) samples and after (1, 4, 8 and 12th) cycles for wetting and drying cycles for three soils types used.

2.1.3 Collapsibility Tests

Tests are conducted by using the odometer device according to (ASTM D5333-03). The soil samples were compacted at field water content and field density for untreated soil and after treatment the samples with cement or calcium chloride in optimum ratio and after (1, 4, 8 and 12th) cycles for wetting and drying cycles for three types of used soil.

2.1.4 The Soils Samples

Three gypseous soil specimens are used. The first one noted as (A) type from Tikrit university site gypseous content 47%,, the second one noted as (B) type from Pharmaceutical Lab in Samarra south of Tikrit gypseous content 32% and the third type noted as (C) from the outskirts of Samarra gypseous content 23%, were taken from depth range (0.5-1.5) meters below the ground surface after excavating the upper soils strata. The properties of three soils are shown in the table (1).

Table 1
properties of three types soil used

Properties		Soil A	Soil B	Soil C
Field moisture content, (ω)%		10	9	9
Specific gravity, (Gs)		2.45	2.58	2.61
Atterberg limits	Liquid limit (L.L)%	26	27	27.5
	Plastic limit (P.L)%	N.P	N.P	N.P
M.I.T Classification	Gravel	16	18	18
	Sand	81	80	78
	Fines	3	2	2
Coefficient of uniformity (CU)		3.5	6.3	6.2
Coefficient of curvature (CC)		0.83	0.64	0.64
Unified Soil Classification		SP	SP	SP
Field unit weight, (γ_f) kN/m³		14.8	13.9	14.5
Compaction Characteristic (Modified Method)	Optimum dry unit weight (kN/m³)	17	16.8	17.8
	Optimum moisture content %	10	11.4	11
Gypsum content %		47	32	23
Total sulphate content (T.D.S.)%		54	37	31
pH value		8.01	8.07	8.12
Organic Materials%		0.12	0.62	0.51

2.2. Experimental Procedure

2.2.1 Improved Soil Specimens with Cement or Chemicals Additives

The soil is treated with 3% of cement or with 5% calcium chloride from weight of dry soil for soil type (B and C). These percentages, according to the research of AL-Helou (2008). As for soil type (A) the improvement was 5% cement or 7% calcium chloride according to the experience of direct shear. The soil is compacted in the molds of the direct shear, the collapsibility tests and unconfined compression test, and extracted from the molds by pressing them, and then left for one week as a treatment period after that examined in the laboratory testing devices to take the results and compare them.

2.2.2 Specimens Used in Wetting and Drying Cycles

The samples are soaked with water for 24 hours (complete wetting). After that the samples are placed in the oven at 45˚C for 24 hours (complete drying). This ends the first cycle of wetting and drying. The process is repeated for the other cycles. 12 cycles of wetting and drying were carried out and the laboratory tests are carried out after the end of each of the first, fourth, eighth and twelfth cycles.

3. RESULTS AND DESCUSSION

3.1. Results Of Direct Shear Tests

From the relationship between shear stress and normal stress the shear strength parameters (Φ) angle of internal friction and (c) the cohesion was calculated. From figure (1) to figure (3) that show the relation between the normal stress and shear stress for untreated samples for the three soil specimens (A, B and C). Figure (2) and figure (3) respectively show the relation between the normal stress and shear stress for soil type B and C treated with 3% cement or treated with 5% calcium chloride whereas figure (1) shows the relation between the normal stress and shear stress for soil (A) treated with 5% or 7% of cement or for treated samples with 7% and 9% of calcium chloride. It can be observed that the cohesion (c) and the angle of internal angle friction (Φ) increased about 50% with cement added and the cohesion (c) of soil increased more than 60% with optimum value of calcium chloride, and the angle of internal friction was increased also for the three soil specimen.

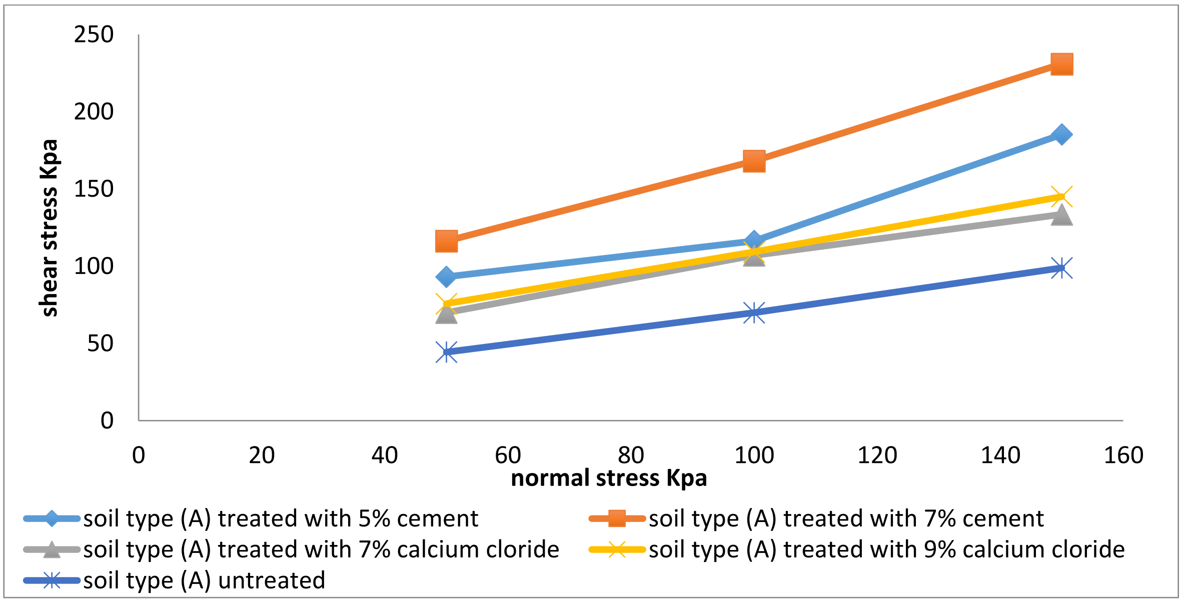

Fig. 1. Direct shear test result for soil type (A)

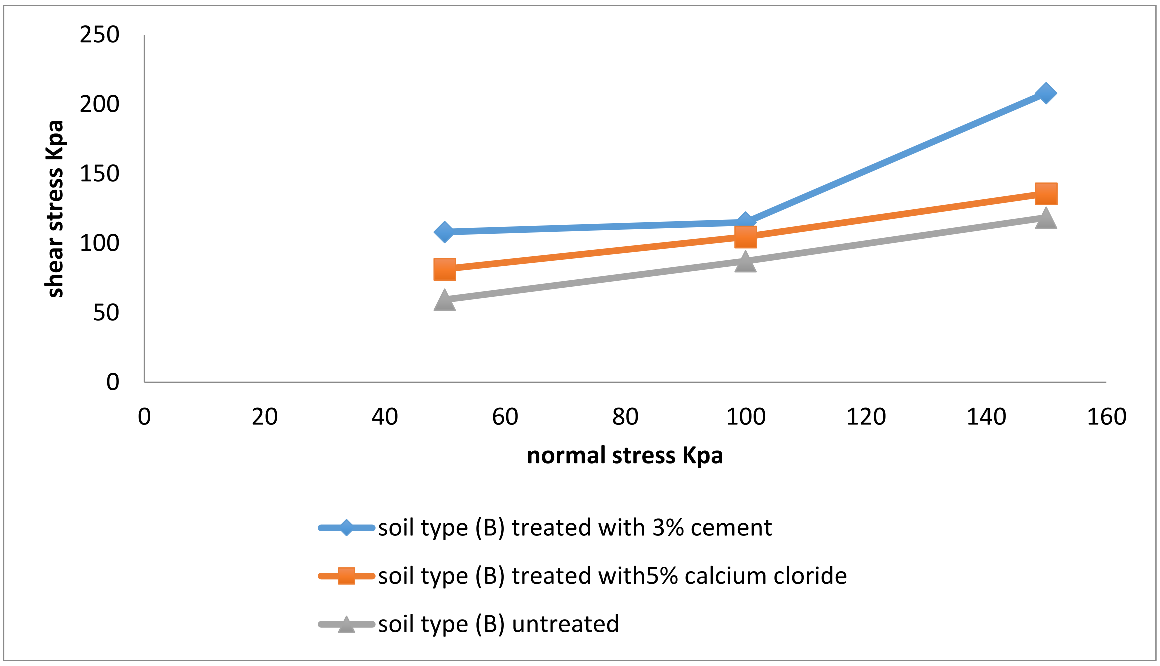

Fig. 2. Direct shear test result for soil type (B)

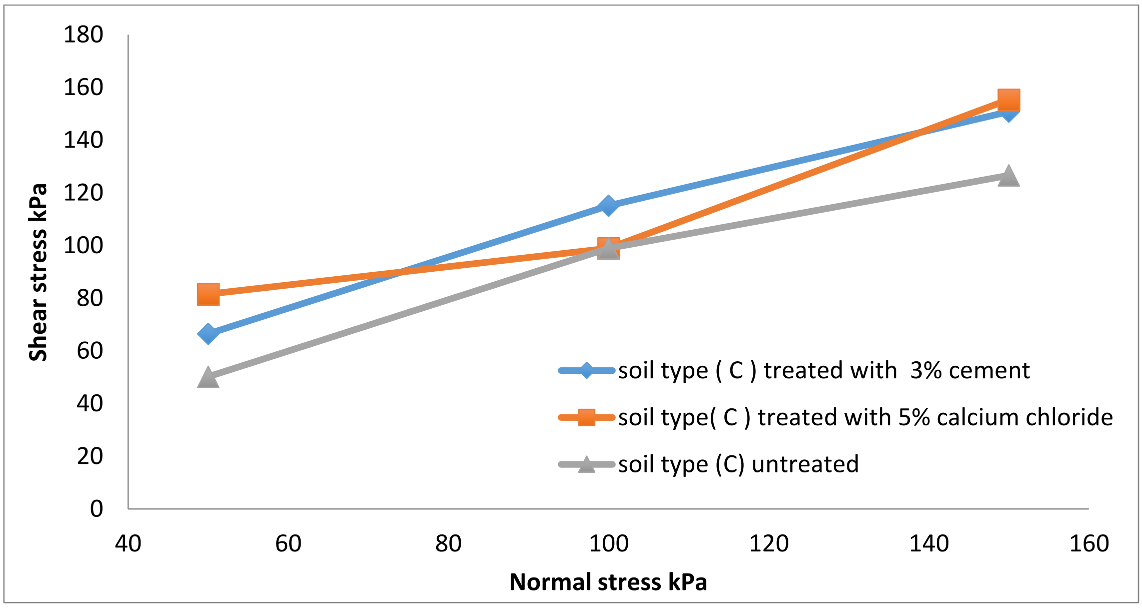

Fig. 3. Direct shear test result for soil type (C)

Figures from (4) to (9) for soil specimens improved with cement with wetting and drying cycles. It can be observed that the cohesion (c) of soil decreased about 25% in the first cycle, also the angle of internal friction decreased 23% for the three types of soil specimens. In the fourth cycle the cohesion (c) and the angle of internal friction was relatively decreased 15% from the first cycle of wetting and drying cycles and remained the same values in (8th and12th) cycle. Figures from (4) to (9) for soil specimens improved with calcium chloride with wetting and drying cycles. In the first cycle it can be observed that the cohesion (c) and the angle of internal friction (Φ) were relatively constant for soil specimens after treatment with optimum value of calcium chloride. In the fourth cycle the cohesion (c) increased about 60% and the angle of internal friction increased about 28% more than those from the first cycle, in the eighth cycle the cohesion (c) returns to decrease 8% and the angle of internal friction decreased about 10% , whereas in the twelfth cycle the cohesion (c) and the angle of internal friction were constant relatively to their values in the eighth cycle for soil specimens .

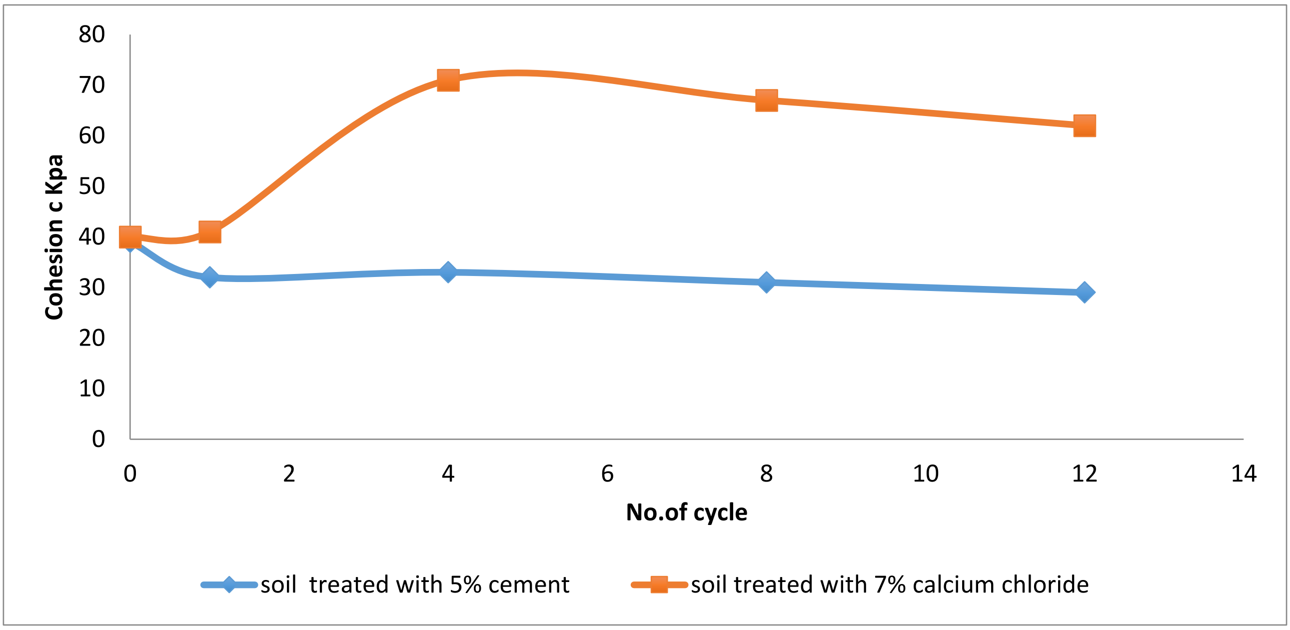

Fig. 4. Relationship between cohesion c and No. of cycles for soil type (A)

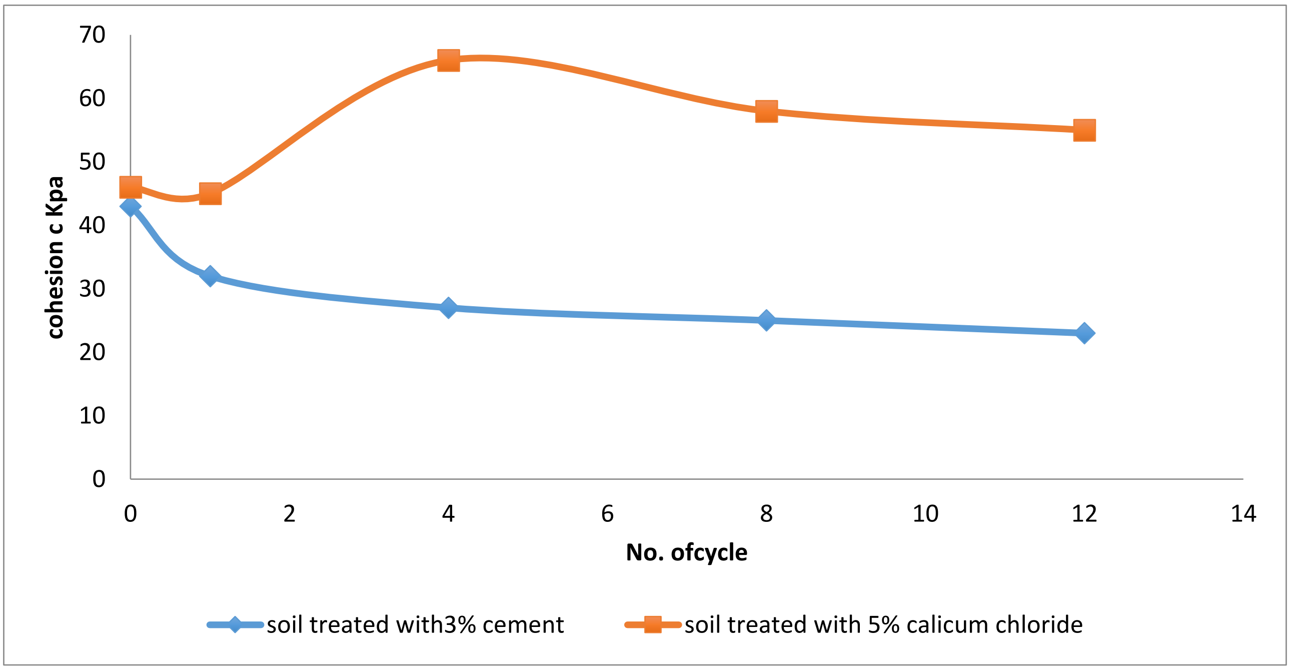

Fig. 5. Relationship between cohesion c and No. of cycles for soil type (B)

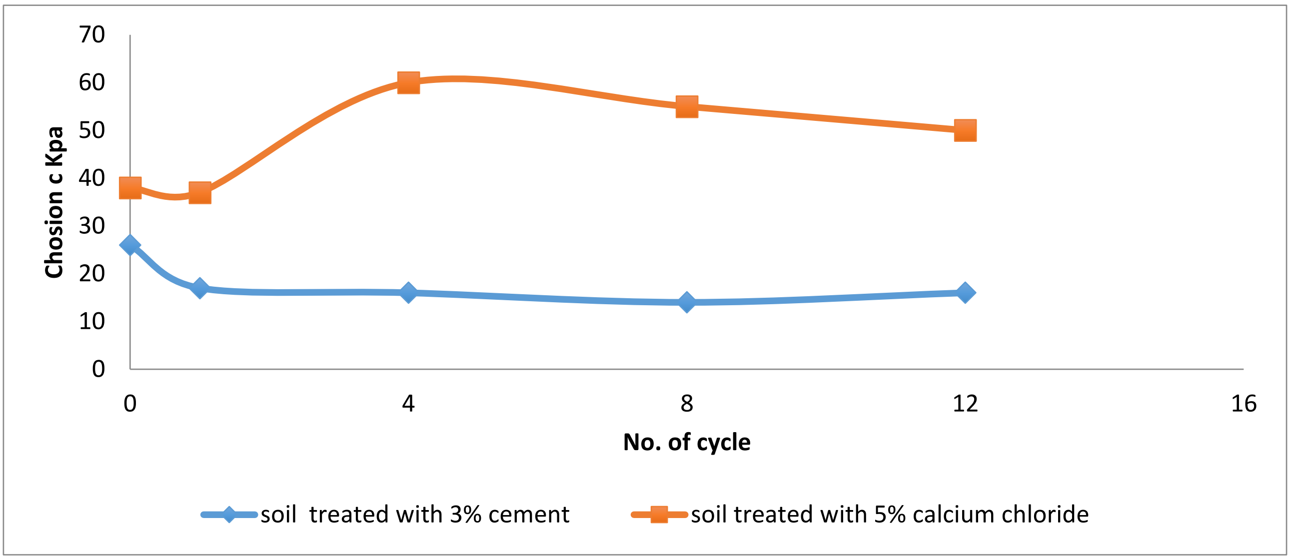

Fig. 6. Relationship between cohesion c and No. of cycles for soil type (C)

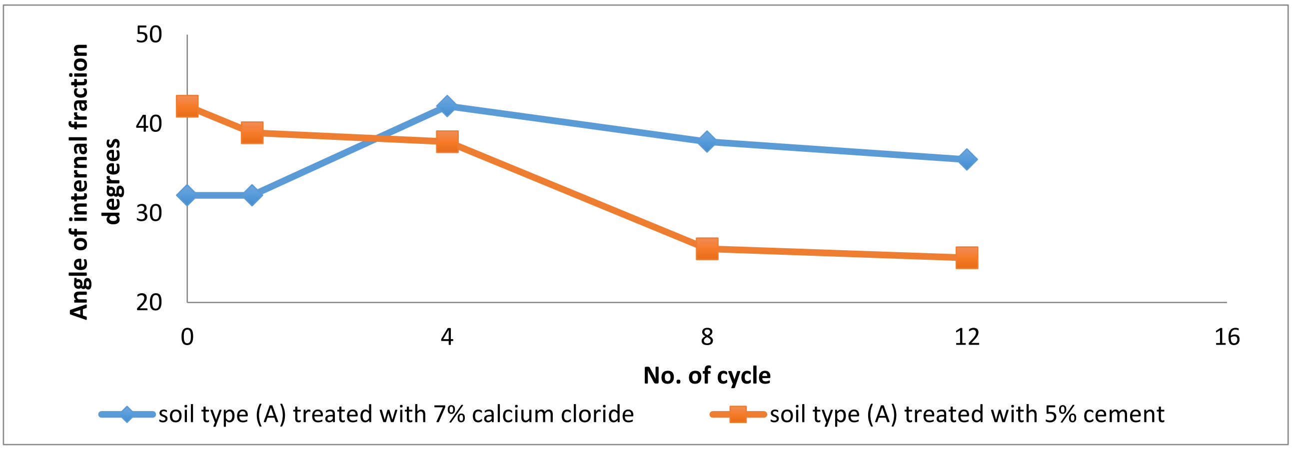

Fig. 7. Relationship between No. of cycle and angle of fraction for soil type (A)

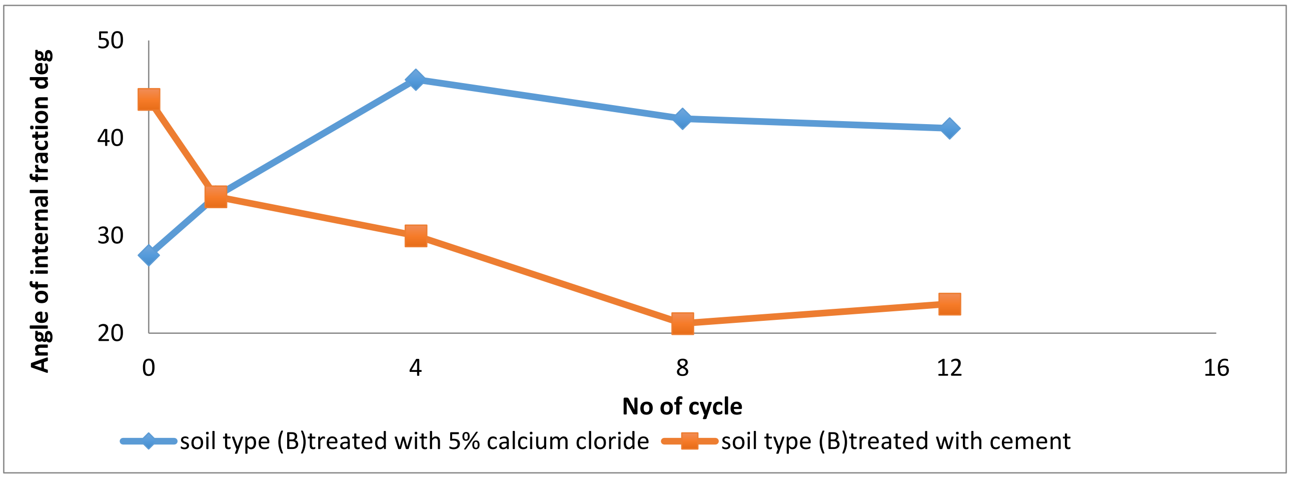

Fig.8. Relationship between No. of cycle and angle of fraction for soil type (B)

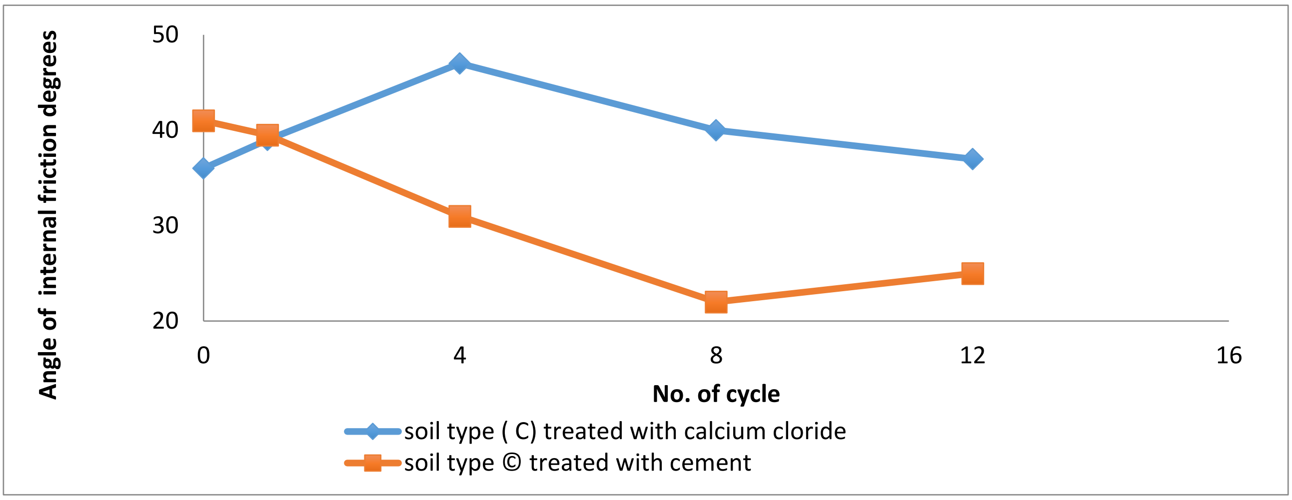

Fig. 9. Relationship between No. of cycle and angle of fraction for soil type (C)

3.2. Results of Unconfined Compression Strength Test

Concerning the effects of wetting and drying cycles for soil treated with cement on the unconfined compressive strength for the soil specimens (A, B and C), it can be observed that after the first cycle the unconfined compressive strength decreased 28% for the three types of soil (A, B and C) whereas in the fourth cycle it decreased by 18%. For the eighth and twelfth cycles it decreased about 15% from the unconfined compressive strength in fourth cycle for the three soil specimens.

The results show the effects of wetting and drying cycles for soil improved with calcium chloride on the unconfined compressive strength for specimens (A, B and C); in the first cycle the unconfined compressive strength increased 10% for all soil specimens. Whereas in the fourth cycle it increased by 60% from its value in the first cycle. For the eighth and twelfth cycles the unconfined compressive strength decreased about 12% from unconfined compressive strength in the fourth cycle for the three soil (A, B and C). The Figures from (10) to (12) shows the relationship between the unconfined compression strength and the number of cycles for soil specimens treated with cement or calcium chloride.

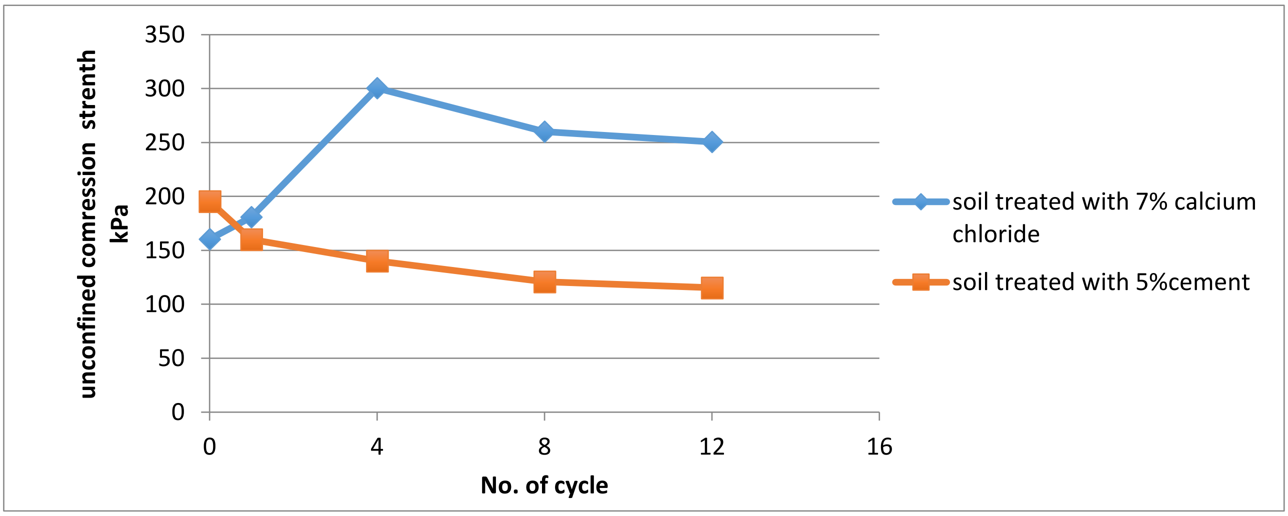

Fig. 10. Relationship between No. of cycle and unconfined compression strength for soil type (A)

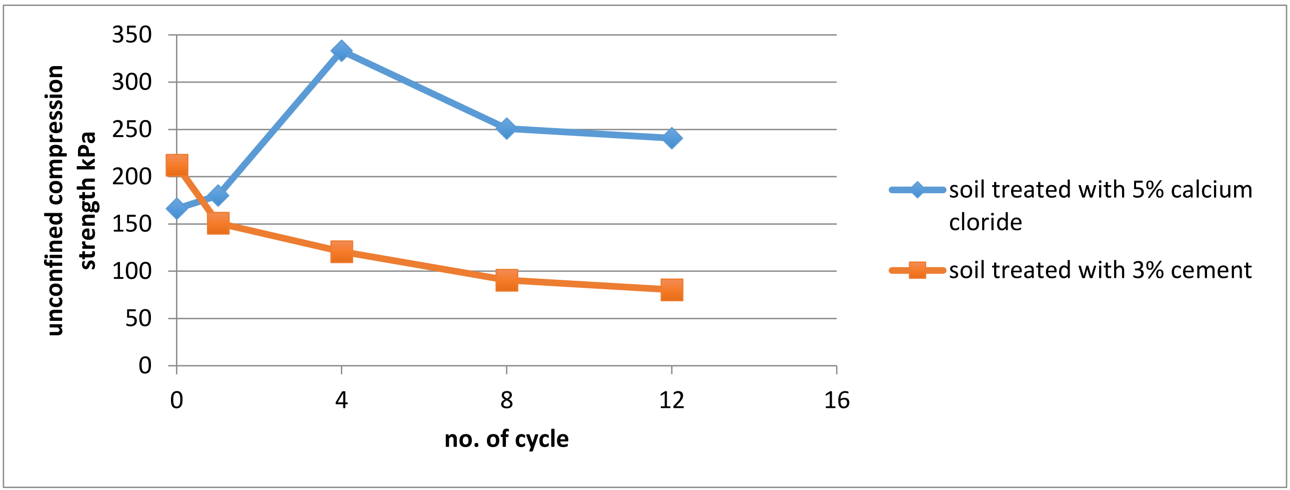

Fig. 11. Relationship between No. of cycle and unconfined compression strength for soil type (B)

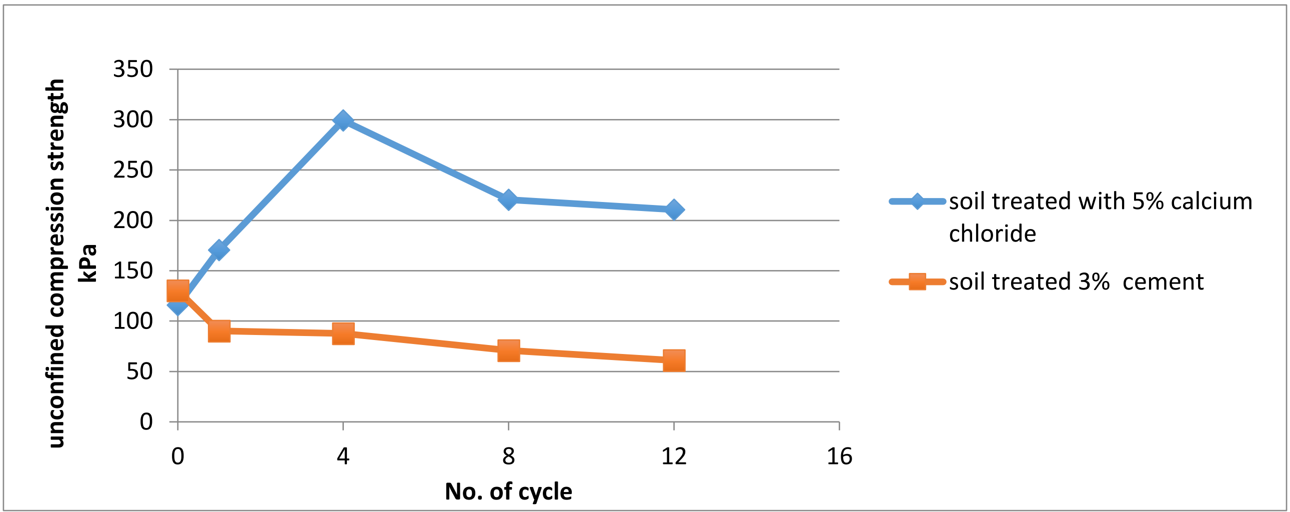

Fig. 12. Relationship between No. of cycle and unconfined compression strength for soil type (C)

3.3. Results of Collapse Potential Test

From the results in tables (2) and (3), it can be observed that the collapse potential decreases with the addition of cement ratio and it decreases with the addition of calcium chloride for all soil samples.

Table 2

The collapse potential for three soils used treated with calcium chloride

Calcium chloride	collapse potential		
	Soil type (A)	Soil type (B)	Soil type (C)
0%	3.6%	4%	3.7%
5%		1.4%	2%
7%	1%		

Table 3

The collapse potential for three soils used treated with cement

Cement	collapse potential		
	Soil type (A)	Soil type(B)	Soil type (C)
0%	3.6%	4%	3.7%
3%		1.5%	1%
5%	1%		

Figures (13) to (15) show the relation between the void ratio and effective stress for samples treated with calcium chloride or cement after wetting and drying cycles. It can be observed that the collapse potential increased with increase in the number of wetting and drying cycles for all soil samples treated with calcium chloride and the collapse potential was relatively constant for all cycles wetting and drying for all soil specimens treated with cement and these values are equal to the collapse potential value after treatment .

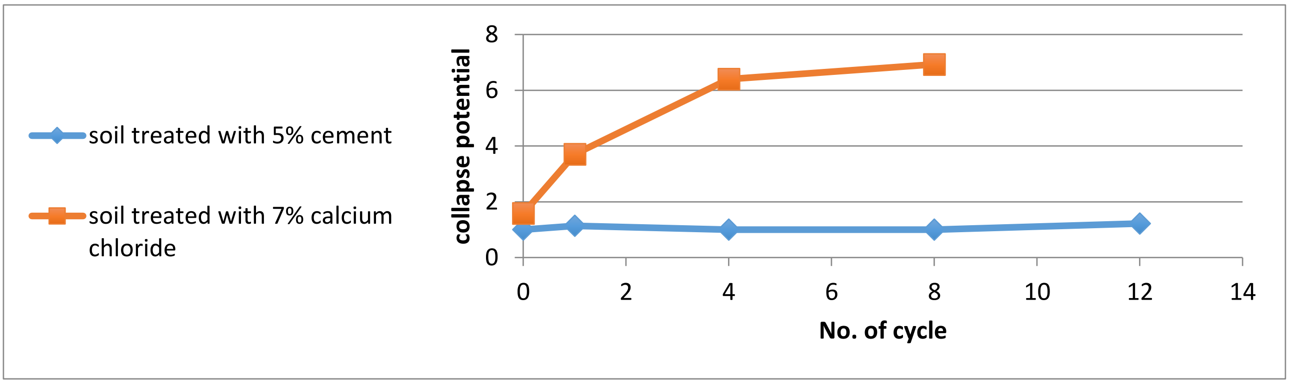

Fig. 13. Relationship between collapse potential and No. of cycle for soil type (A)

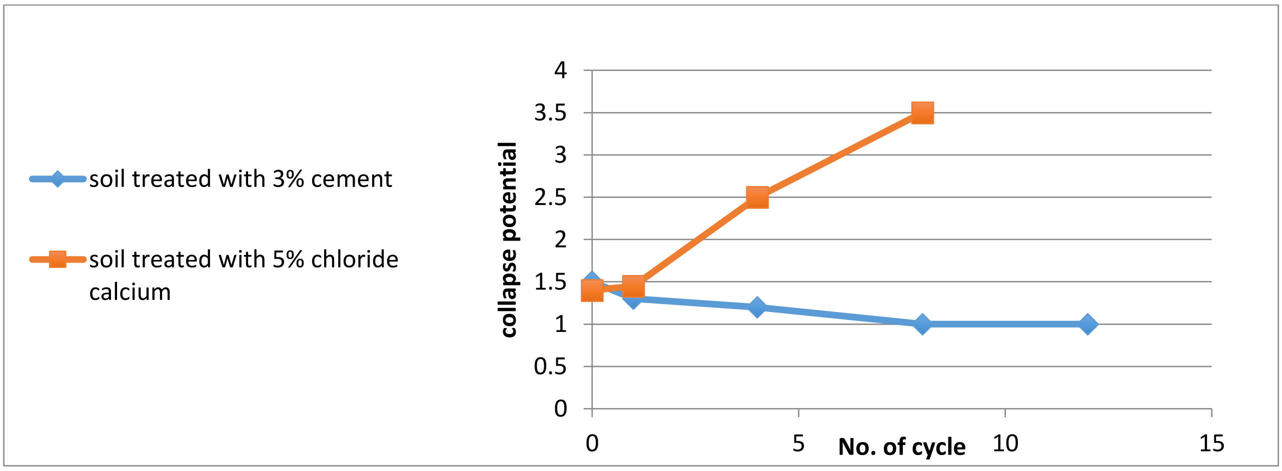

Fig. 14. Relationship between collapse potential and No. of cycle for soil type (B)

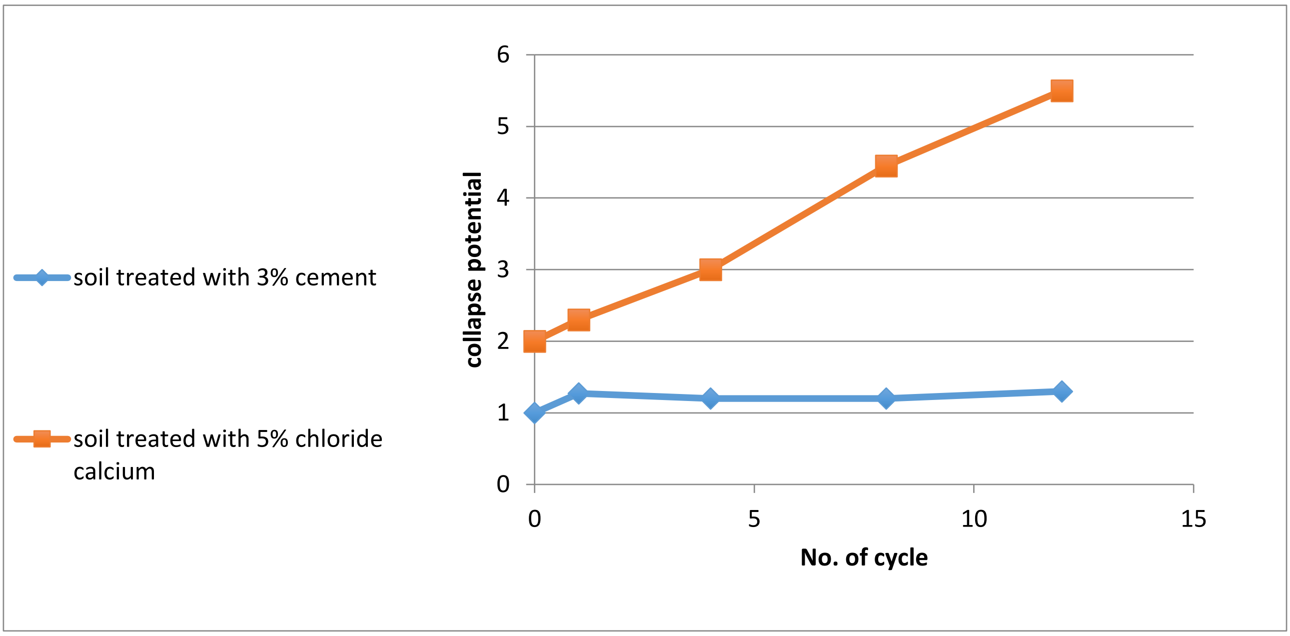

Fig.15. Relationship between collapse potential and No. of cycle for soil type (C)

Figure (16) shows the relationship between the number of cycles and collapse index for samples treated with cement ratio of 3% for soil (B and C) and 5% for soil (A) after wetting and drying cycles. It can be observed that the collapse index increases by 20% in the first cycle and continues in increasing about 22% from the first cycle with the other cycles even to the twelfth cycle for all types of soils.

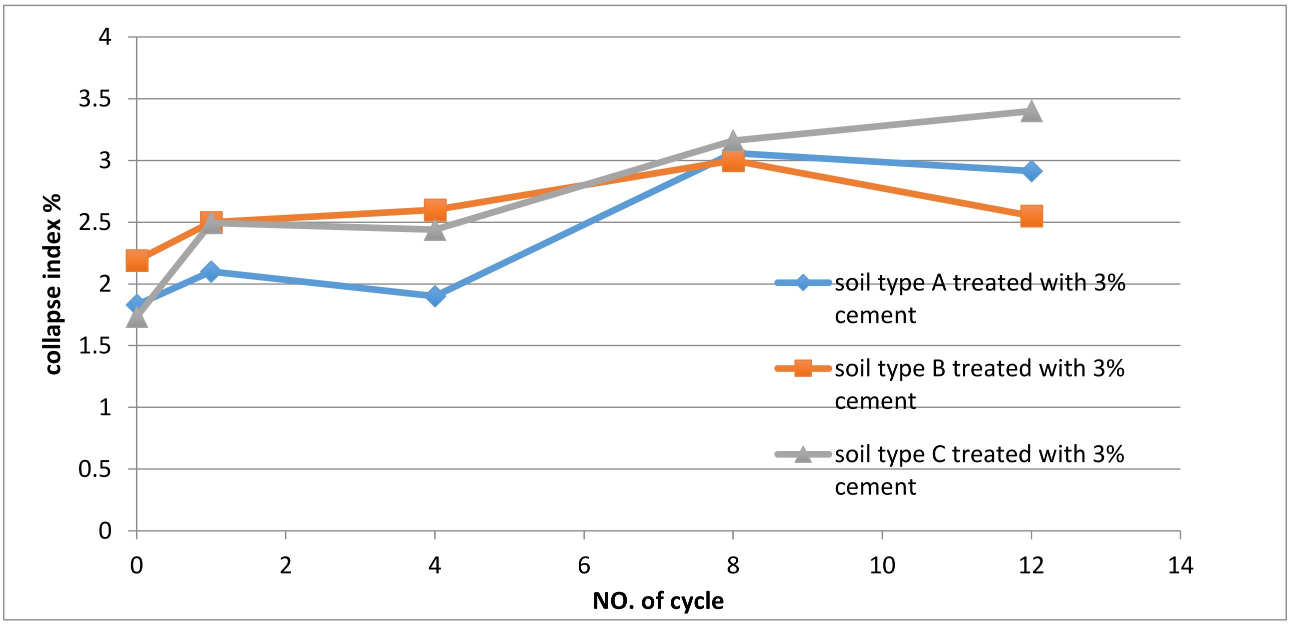

Fig. 16. The relationship between number of cycles and collapse index for samples treated with cement

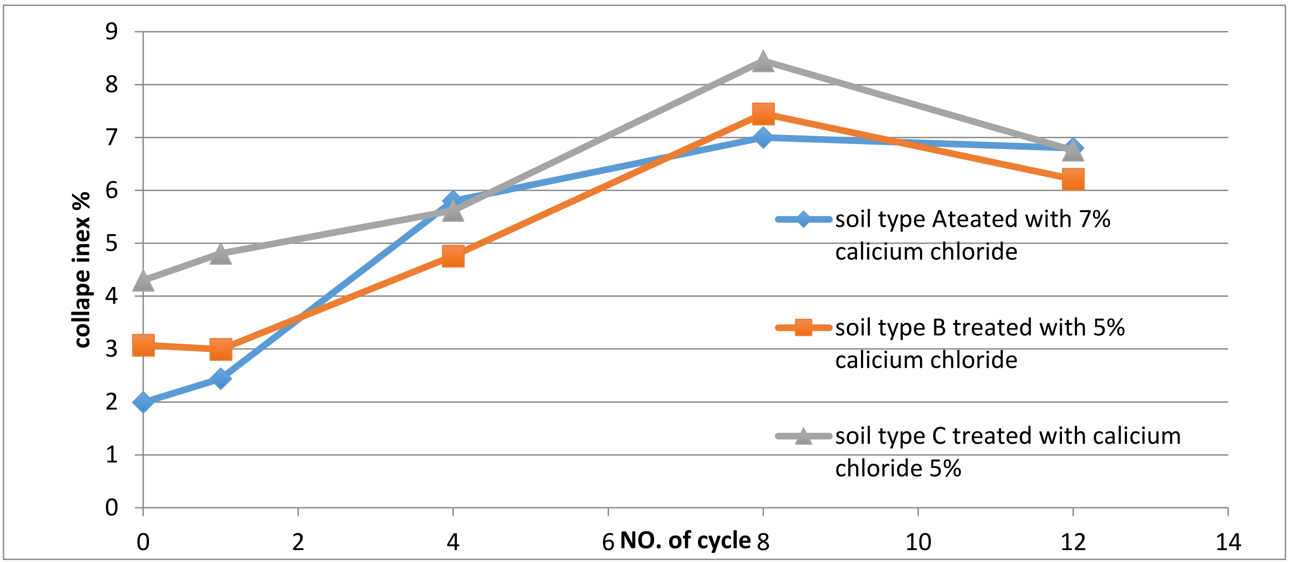

Fig. 17. The relationship between number of cycles and collapse index for samples treated with calcium chloride

The relationship between the number of cycles and collapse index for samples treated with calcium chloride ratio of 5% for soils (B and C) and 7% for soil (A) after wetting and drying cycles. It can be observed that the collapse potential increases by 26% in the first cycle. For the eighth and twelfth cycles increased about40% from the collapse index in the fourth cycle for the three soil specimens all types of soils.

4. CONCLUSIONS

The main conclusions of the present study can be summarized as follows:

1. For the three types soil treated with calcium chloride the cohesion (c) increased 60% and the angle of internal friction (Φ) increased by 70% and collapse potential (cp) of soils decreased by 70%.

2. For soil treated with cement the cohesion (c) increased by 50%, and the value of the friction angle (Φ) increased by 50% and collapse potential (cp) of soils decreased by 65% for the three types of soil used.

3. Effect of wetting and drying cycles on soil samples improved by cement cohesion decrease by (25%) in the first cycle and continue in slight decreases with the other cycles to the twelfth cycle. Also, the value of the friction angle decreases 23% in the first cycle and continues with little decrease in the other wetting and drying cycles and collapse potential (cp) remain with the same value in the first, fourth, eighth and twelfth cycles, which is the value after treatment of gypsum soil with cement and for all soil specimens. From the effects of wetting and drying cycle individually on various soil properties it can be concluded that the durability of shear strength parameters decreased in effect.

4. The properties of the soil sample which improved with calcium chloride in the first cycle show that the cohesion remains with the same values of cohesion after treatment for the three soil samples, while in the fourth cycle, the cohesion increased up to 60% higher than its value in the first cycle. Thereafter, in the eighth cycle, cohesion is about 8% lower than the fourth cycle and remains approximately the same value in the 12th cycle with slight decrease. Also, the value of the friction angle in the first cycle almost has the same values until the fourth cycle then the friction angle increases by 28% and decreases 10% in the eighth cycle and it remains with the same value even to the (12th) cycle and collapse potential increases from one cycle to another

about 30-50% for all soil samples. There is a slight effect at the number of cycles of wetting and drying after the fourth cycle; major effects can be noticed in the first and four cycles.

REFERENCES

(1) Al-Daood, A., Bouasker, M. and Al-Mukhtar, M. (2014) "Geotechnical Properties of Lime Treated Gypseous Soil"Applied Clay Science,Vol. 88-89, pp. 39-48

(2) Abid Awn, S.H. (2011)"Improvement of Gypseous Soil by Pre-Wetting" Diyala Journal of eng. sciences, Vol.04, No.01, pp.71-82

(3) Zukri, A. (2012) "Pekan Soft Clay Treated With Hydrated Lime as a Method of Stabilizer", Procedia Engineering Part 3, Vol.53, pp.37-41.

(4) Yuns, N.Z., Wanatowski, D. and Stac, L.R. (2012) "Effectiveness of Chloride Salts on The Behavior of Lime-Stabilized Organic Clay", Int. J. of GEOMATE, Vol.3, No.2 PP.407-412.

(5) Lucian, C.(2006)"Geotechnical Aspects of Bulding on Expansive Soils in Khibaha, Tanzania", KTH Architecture and the Built Environment Vol.12 pp.1-150.

(6) AL-Kiki, I.M. and AL-Atalla, M.A. and AL-Zubaydi, A.H., (2011) ((Long Trem Strength and Durability of Clayey Soil Stabilized with Lime)) Eng. and Tech. Journal , Vol.29, No.4, ,Pages 725-735 .

(7) AL_Helou, Karim Hadi Ibrahim 2008 ((Improving the compressibility of gypsum soil)) University of Technology, Baghdad, Iraq Civil Engineering Journal, Issue 12 Pages 1-8

(8) AL- Neami, M.A. , (2010) "Improvement of Gypseous Soil by Clinker Additive" ,Engineering and Technology Journal , Vol.28, No.19, pp.5822-5832

(9) Al-Obaidi, M.A. And AL-Kiki , I,M. and AL-Zubaydi A.H., (2010) ((Strength and Durability of Gypseous Soil Treated with Waste Lime and Cement)) University Of Mosul -Collage of Eng.

(10) Snodi, L.N. and Hussein, I.S. (2019) "Tire Rubber Waste for Improving Gypseous Soil", IOP Science journal Vol.584 , pp.1-7