Improvement of Earth Canals Constructed on a Gypseous Soil by Cement

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Abstract

Gypseous soil is a collapsible soil(problematic soil) , it supports heavy loads in a natural water content, but with increased water content, they undergo a significant reduction in volume that's belong to dissolve of gypsum content .Many research works have been done to investigate the behavior of these soils. All these works indicated that the use of additives can significantly reduce the settlement and corrosion of soils.

This research presents the results of an experimental study for treating soil. The soil was brought from Karbla Governorat of gypsum content (42.55%). Many tests were employed on treated and untreated soil. Different water cement ratio (W/C) with different curing time used to investigate the best ratio of cement and the minimum curing time which decreased the collapsibility of earth canal with a gypsums soil. The effect on improvement of gypsums soil was made by using two percentages (5, 10) % by volume with three ratio of water to cement (W/C) of (2, 3, 4)% , a mixture sprayed above compacted soil. The results marked that (2) % of water to cement ratio in both percentage of volume (5 % ,10%) decreases the collapsibility sharply with curing time 14 days.

Key words: Gypseous soil , collapsibility , water to cement ratio , curing time .

1.Introduction:

The stability of earth channels depends on many factors such as strength of bed channels, slope and bank materials and the flow characteristics.

Erosion that occurs in the earth canals is the dangerous problem especially when it is constructed on

gypsums soil. As well as there are several places in the world has a contaminated soil known as gypsiferous soil.

Gypesous soil cover a bout (31.7%) of the surface sediment in Iraq with gypsum content (about 10-70%) **Ismail (1994)** and 0.6% of the world area **Alphen and Romero, (1971)**. The gypseous soil are considered as collapsible soils , the gypseous
soils consist of gypsum which is a mineral salt known as calcium hydroxide sulfate ($CaSO_4.2H_2O$), **Ahmad et al., (2012)** .
It has high bearing capacity and it is hard unless the water infiltrated into it.
The water causing dissolve of gypsum content and leads to soften the soil which leads to several foundation problems due to collapse of soils structure and formation of cavities.

Therefore, Many research have been conducted to study the behavior and properties of this soil causing a problem observed when construction above the gypseous soil. Different materials were suggested as additives for improvement this type of soil such as cement, clinker and other.
Akroyd (1970) studies the cement effect on soil properties with increased strength of cement content and increased bearing capacity, durability to wet / dry cycle increases .

problem of gypsum

Al-Hadithy (2001) investigated the effect of cement addition to improve the mechanical behavior of gypseous soil using different percentage of cement 3%, 5%, 7% 10%. He used gypseous soils with different gypsum content (18%, 29%) from a different position. He showed that there was a considerable reducation of compression index Cc to 50% curing 7 days and after addition of 3% cement.
Alrobaiee (2008) investigated the effect of adding cement on stabilization and bearing capacity of soil take place from Hilla city. He used different ratios of cement (5%, 8 %, 13% and 15 %) by weight of dry soils.
Al-Hello (2008) studied the improvement of compressibility of gypseous soil for Samarra-salah aldeen gavernort with a gypsum content of 32% many test were carried out on soil by adding Portland cement and calcium chloride he founded that the soil can improve when he added 3% cement and 5% of chloride .
Al-Neami (2010) studied the improvement of gypseous soil by clinker additive for gypseous soil with gypsum content (40%) from Al-Exandria region, Babylon Governorate used 3 percentages of clinker (2, 4 and 6 %) founded the clinker percentage with (4%) decrease the collapsibility sharply.

AL-Numani (2010) studied Effect of three different additives on the gypseous soil taken from the Tar area west of Najaf with Gypsum content (35%) poorly graded soil. The researcher used cement with a percentage between (4-8%) in terms of weight, the researcher found that the best improvement by adding a mixture of cement and ceramics where the maximum dry density increases only with increases in mixing content while the reverse is true for the optimum water content.

Ramaji (2012) studied stabilization of soil using low-cost methods, based on Portland cement , lime and fly ash and other All these methods may have the disadvantages of being ineffective.

Gomez and Anderson (2012) present the Design of soil and cement mixture, results and field laboratory conduct. Cement and soil mixtures are prepared with varying cement content ranging from 4% to 6% by weight. The mix design requirement was to determine the cement content necessary to obtain a minimum of costly and expensive compression strength.

Mahawish (2013) studies the Chemical stability of ground gypseous soil for road construction in Iraq the researcher stabilized gypseous soil with various percentage of cement to determine the effect of Phosphorus pentoxide when it mixed with other additive the soil was brought from Abu Ghraib city with a gypsum content 35% founded that by adding 6% of cement and 1% of Phosphorus pentoxide will improve CBR of the soil.

Eskisar (2015) the experimental results show the use of cement to stabilize and modify the medium plastic clay.The author mixed the soil with Portland cement with two percentages of 5 and 10% dry weight of water content of 40 and 60%
The samples curing time ranges from 7 to 28 days. The consolidation tests results indicated that the preconsolidation by increasing the cement content the pressure increased .

Raman et al (2016) studies the stabilization of the loose soil stratum by grouting the soil with the cement . The Cement grout are injected into the soil with different ratio of 10:1 (Water: Cement), 8:1, 6:1, 4:1 with the low pressure. After 3 and 7 days of curing the strength properties of the grouted soil are determined. From this study it is proved that the grouting can be an effective method for reducing the permeability of the grouted soil sample and increasing the strength of the grouted soil sample in loose and medium dense state.

2 Experimental Program :

2.1 Material

The soil used in this study was brought from Karbla Governorate with gypsum content 42.55%. The soil taken from (0.5 – 1) m depth below the natural ground surface then packet in nylon bags ,then was conveyed to hydraulics laboratory, Engineering College, University of Baghdad, for testing. Before conducting any test it was sieving from sieve 4# for compaction test.

2.2 Cement The properties of cement used in this study are shown in **Table (1)** its also shows the properties of the soil .

Table. 1 Chemical and Physical Tests for Soil and Cement

Soil		cement	
Gypsum Content (%)	42.55%	Na_2O	1.436%
		SiO_2	17.97%
		Al_2O_3	2.79%
Maximum Dry Unit Weight (kN/m3)	16.5%	Fe_2O_3	5.451%
		CaO	69.18%
Optimum Water Content(%)	12.8%	MgO	1.445%
		K_2O	0.5648%
		P_2O_5	0.0602%
Specific Gravity (Gs)	2.55	SO_3	2.88%
		MnO	0.267%
Soil Classification According to (USCS)	S.P.	CuO	0.00593%
		ZnO	0.01228%
		TiO_2	0.253%

Test Program

The test program in this study can be summarized in the following groups:

The first classification tests were performed including physical and chemical tests. Physical tests include grain size distribution, specific gravity and water content. standard compaction tests have been conducted to determine the relationship

between moisture and density of natural soil as follows:

Physical Tests

1.Grain Size Distribution

Distribution of grain size was determined according to **[10]** with

dry sieving **Fig.1** shows the grain distribution curve for the soil sample. The figure shows clearly that the soil sample is classified as a sand poorly graded soil according to the Unified Soil Classification System (USCS).

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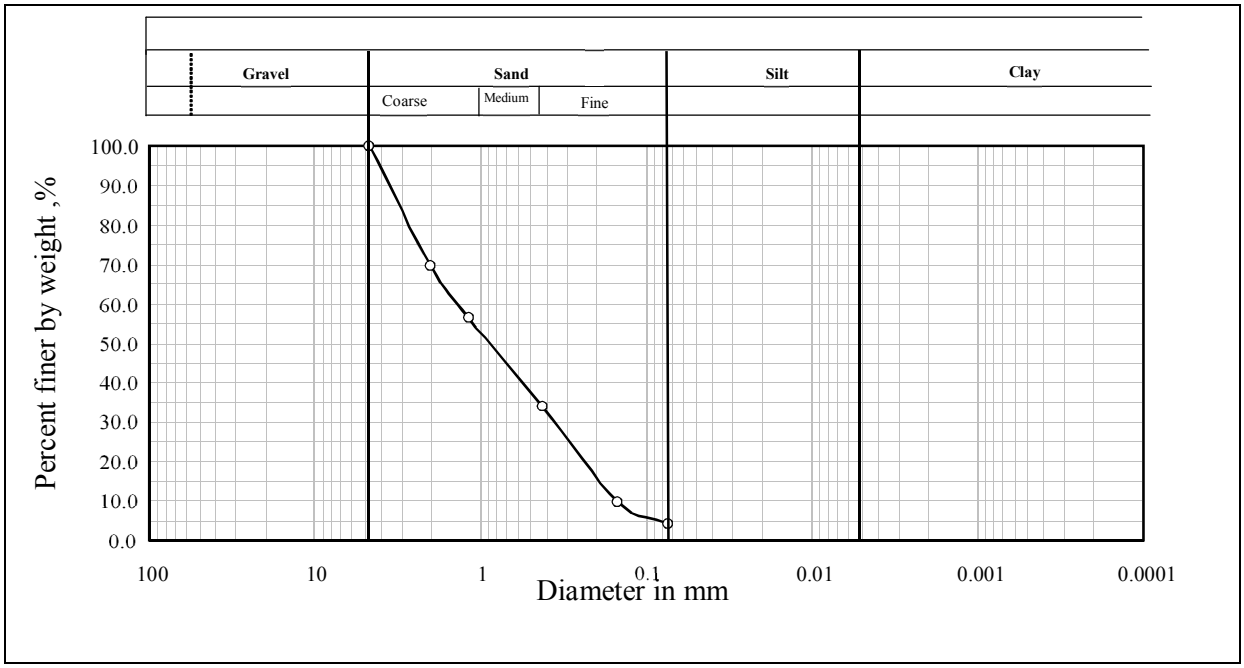

Fig. 1 Grain size distribution curve for soil used in bed channel construction.

2.Specific Gravity

Specific gravity was determined according to **[11]** . Kerosene was used instead of distilled water due to the gypsum solution **[14].**

Chemical Tests

1.Gypsum Content :

The content of the gypsum found in the manner method presented by **[18].**

Several methods and techniques have been suggested to determine the gypsum content. One of these methods is the hydration method of **[11]** which is used to determine the gypsum content of the natural soil in this study. The hydration method can be summarized as follows: The sample is oven dried at temperature of 45°C until the sample weight remains constant. This weight is recorded as $W45^{o}$ *C*. After that The sample itself is dried at 110°C temperature for 24 hours. Then recording the weight as $W110^{o}$ *C*. Content of gypsum (χ) is calculated

according to the following equation:

$$X = [(W_{45^\circ} - W_{110^\circ})/W_{45^\circ}] \times 477.8 \quad \ldots (1)$$

Where:
W_{45^o} = weight of sample at a temperature of 45ºC.
W_{110^o} = weight of sample at a temperature 110 ºC .

2.Compaction Test :
The Standard Proctor compaction tests on untreated were conducted to determine the relationship of moisture unit weight according to and the optimum moisture content **[10]**.
Control of gypsum soil compaction also requires slow heating at temperatures 45ºC for 48 hours rather than 24 hours for nongypseous soil **[5] Fig. (2).**

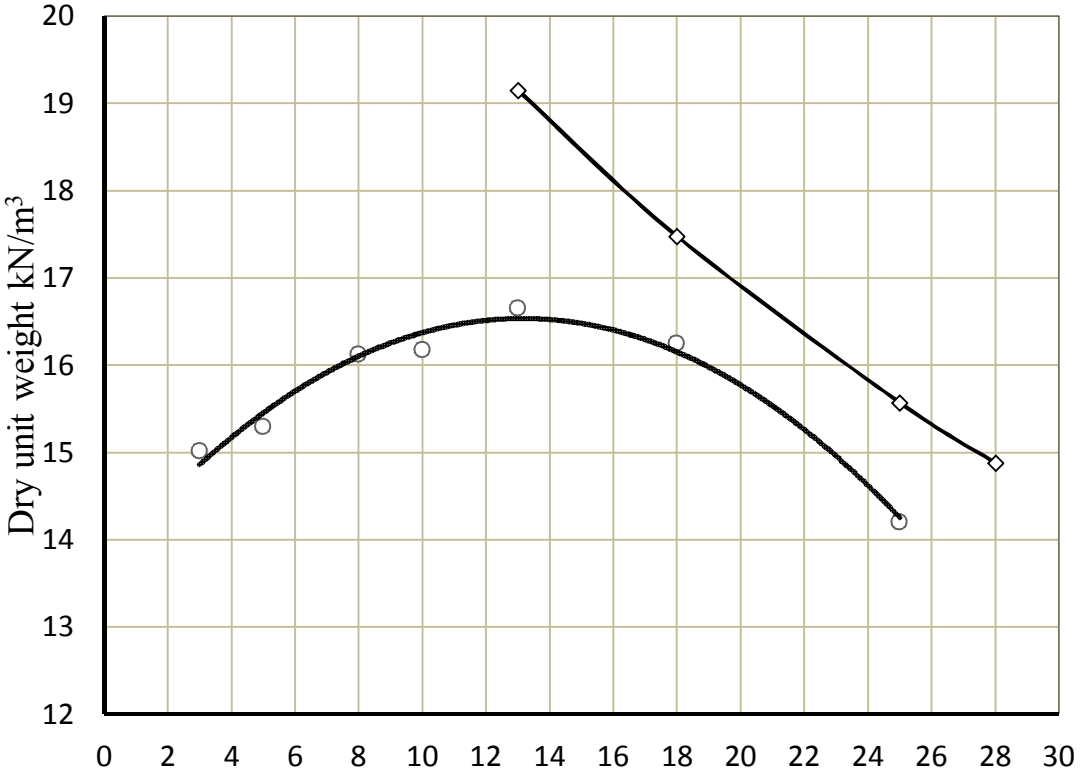

Fig.2 Compaction test.

The Flume

The test was by making a mixture of cement and water and spray it a bove the compacted soil . First the soil was weighted and then
mixed with water by hand then coneveyed to the flume and compacted by compactor tool that shown below in the **Fig. 4** .After that the cement weighted and mixed as two percentange 5% and 10% by volume with three percentange of 2,3 and 4 % water to cement ratios .

Then the mixture put in the sprinkler and then sprayed a bove the soil to formation a rank of cement coverd the soil **Fig. 5**. Then the flume is opreated **Fig.6** and a batch of measurements was taken after 7 ,14 ,28 days to the level of the soil **Fig.6** .Two gates are put at the begining and the end of the flume to keep the water within the flume after turn off it **Fig .7**.

Fig .3 The Flume.

Fig.4 compacted soil and the compactor .

Fig.5 Test Procedure.

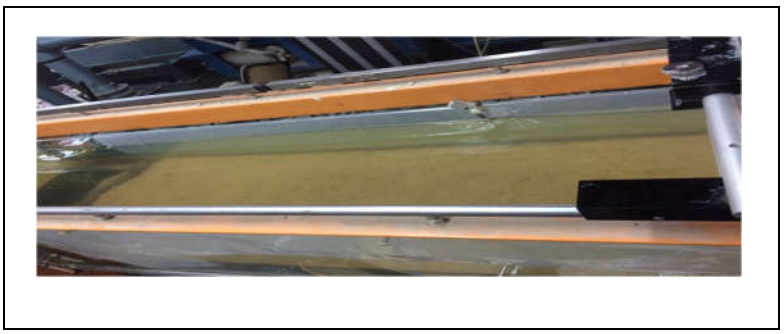

Fig.6 The flume during Operation.

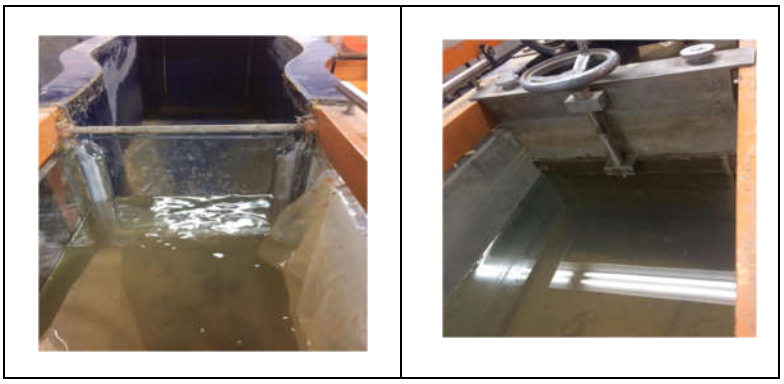

Fig.7 The Gates

Results and Discussion

According to the Unified Soil Classification System **[10]**, the soil can be classified as poorly graded sandy soil **Fig.1 .**

The gypsum content of the soil is 42.55% and specific gravity (2. 55).

Before conducting any test the soil was sieving from sieve 4# for compaction test.

The collapse potential is calculated according to the definition of **[16]** in which:

C.P. = DH / (H_0) ...(2)

Where:

DH = difference in height of soil specimen before and after soaking.

Ho = initial height of soil specimen.

The gypsum content it's also measured after treatment of the soil **Fig.8** and **Fig .9**. **Fig. 8** show the gypsum content with cement of 5 % after treatment. As showing in figure the gypsum content decreased by increasing the (w/c) ratio that's belonging to the effect of water on gypseous soil. **Fig. 9** showed the gypsum content with cement of 10% after treatment. As showing in figure the gypsum content decreased after adding 2 % (w/c) ratio then increase to reach to approach value of the natural soil. At 4% of w/c ratio the value of gypsum same as the 3 % of w/c .The change of gypsum content belong to the effect of water on the soil.

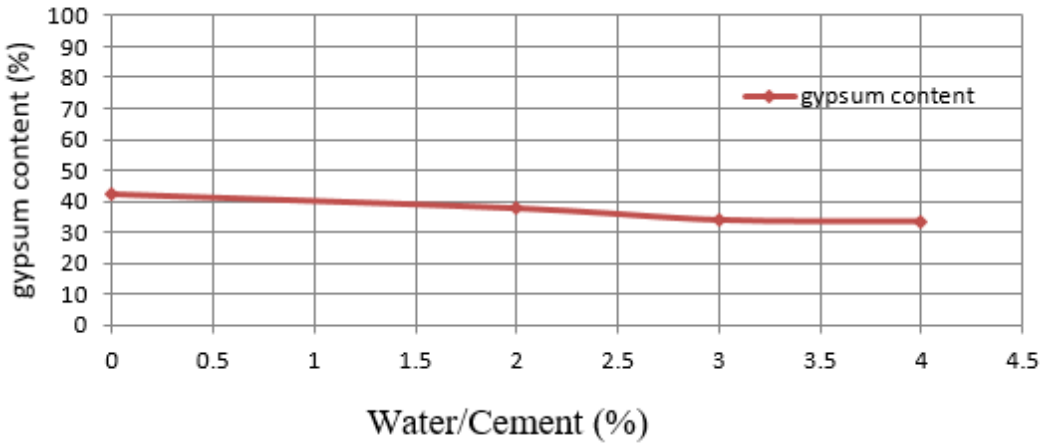

Fig .8 Gypsum content of soil with 5% of cement by volume after treatment.

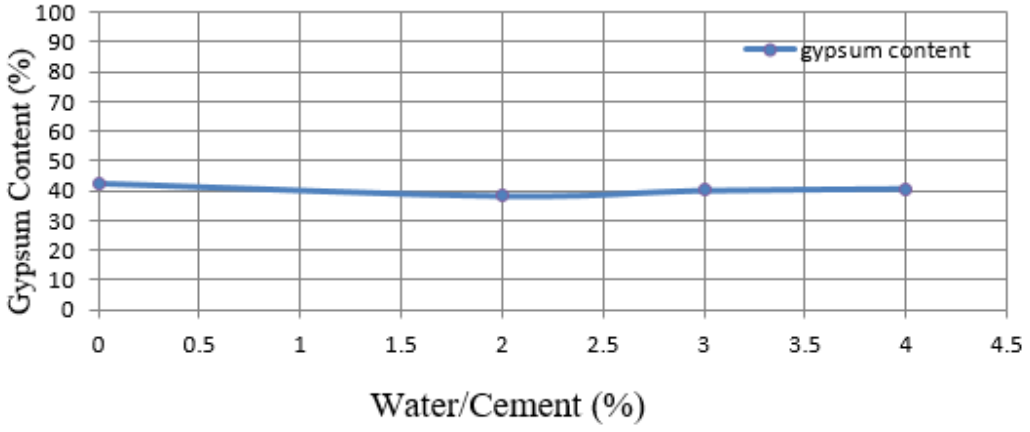

Fig .9 Gypsum content with 10% of cement by volume after treatment.

Fig. 10 shows additives content which plotted versus collapse potential (cp). It showed that collapsibility of soil decreases by adding the water cement mixture to the soil. As shown below the collapsibility of natural soil is high with a large rate of increasing in collapsibility after 28 days. This value of collapsibility decreases by adding 2 % of w/c ratio in comparison of natural soil state. After 28 days the collapsibility changes in a very small rate. By adding 3% of (w/c) the collapsibility gave are similar to the value of 2 % of (w/c). The ratio of 4 % of (w/c) added to the soil increased the collapsibility with compare the other ratio. From above we noted that the collapsibility of soil decrease by adding 2, 3 % of water /cement ratio and increase by adding 4 %. The reason of that may be belong to the density of mixture it light (2, 3%) which helped it to penetrated easily into the soil and make material covered soil particles and prevent the water to enter into the soil. the rate of 4 % its became heavy and the mixture couldn't penetrated into the soil and made a layer of cement covered the soil.

It was found that the collapse potential decreases sharply at (2) % cement and continues in decrease with (3%) cement, but at (4%) cement,the collapsibility represented by collapse potential returns to increase with a little value. This may be due to filling the voids in the soil skeleton by cement material, which increases the cementing bonds between particles and decreases the solubility of gypsum.

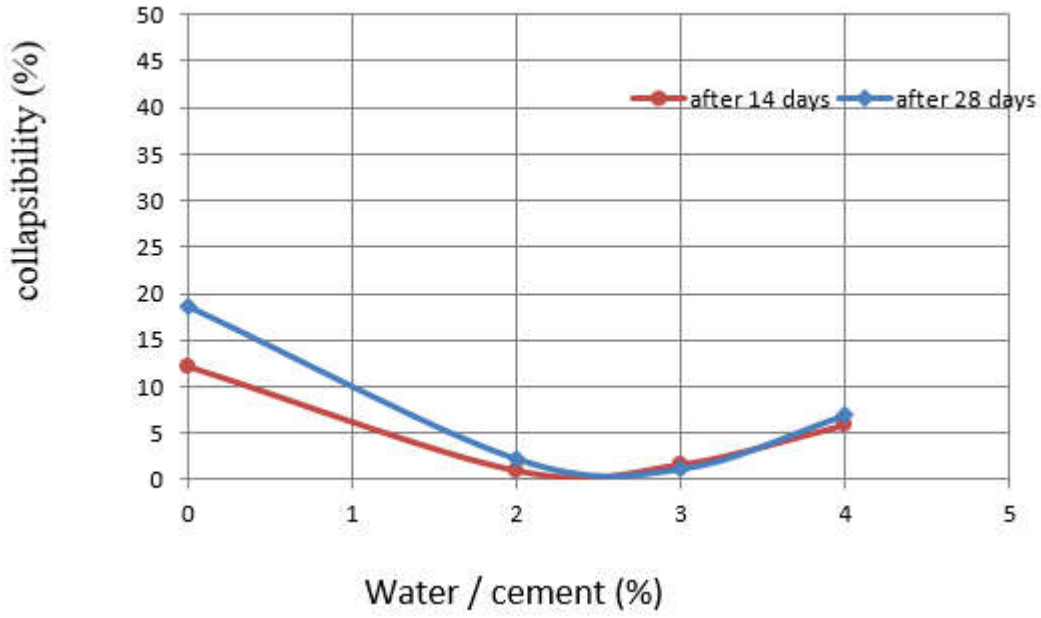

Fig. 10 Effect of treatment of cement on average collapsibility of 5% by volume.

Fig. 11 showed that collapsibility of soil decreases by adding the water cement mixture to the soil. The collapsibility of natural soil is high with a large rate of increasing rate in collapsibility after 28 days. This value of collapsibility decreases by adding 2 % of w/c ratio in comparison of natural soil state. The collapsibility change in a very small rate after 28 days .The ratio 3% of (w/c) increasing the collapsibility with comparison with 2 % of (w/c) while the ratio of 4 % of (w/c) added to the soil increased the collapsibility.

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adding 2, 3 % of water /cement ratio and increase by adding 4 %. The reason of that may be belong to the density of mixture it light (2, 3%) which helped it to penetrated easily into the soil and make material covered soil particles and prevent the water to enter into the soil. the rate of 4 % its became heavy and the mixture couldn't penetrated into the soil and made a layer of cement covered the soil.

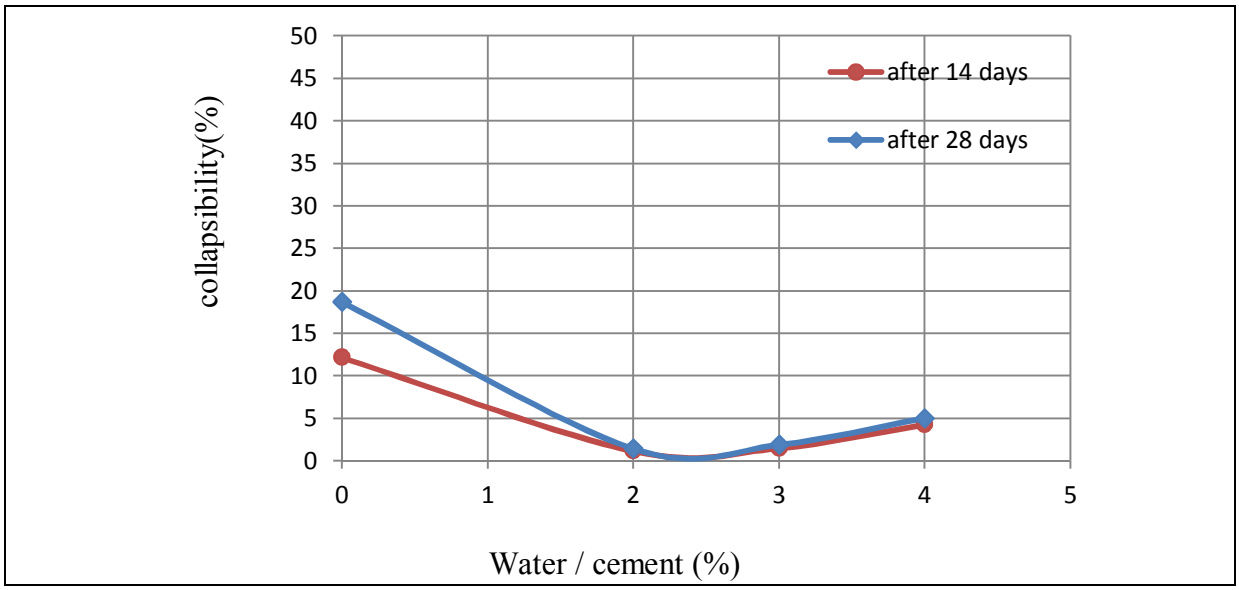

Fig. 11 Effect of treatment of cement on average collapsibility of 10% by volume.

A comparison between the results of collapsibility for the treated and untreated soil considers in this study and previous studies plotted in **Fig.12** and **Fig.13** The comparison shows that the treatment of gypseous soil with cement water mixture improve the collapsibility in a good manner as compared to other method of treatment. **[6]** He had chosen three percentages of clinker additive (2, 4 and 6) %. soil with a gypsum content (40%) from Al-Axandria region, Babylon which treated the gypseous soil by clinker additive for gypseous soil .He investigated that by adding

Fig.12 and **Fig.13** the other study was selected for comparison **[4]** used cement for improving the gypseous soil with a gypsum content of 32% by adding Portland cement and with a different ratio of cement (1,2,3)%.He founded that the soil can improve when added 3% of cement and 5% of chloride .

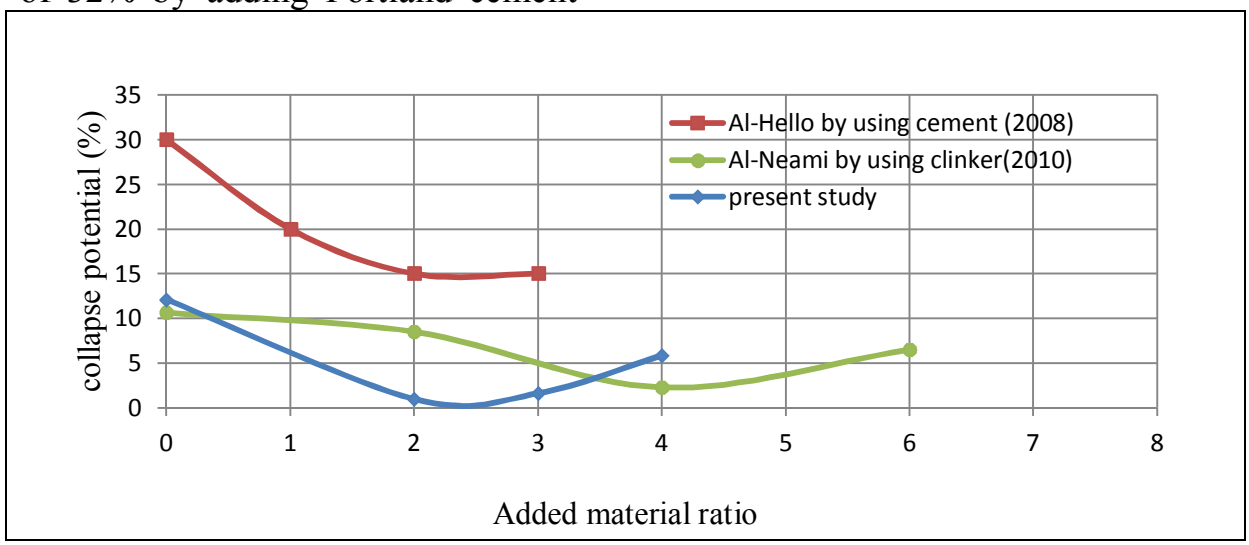

Fig .12 The relation between the clinker and collapsibility and cement mixture of 5% by volume after seven days.

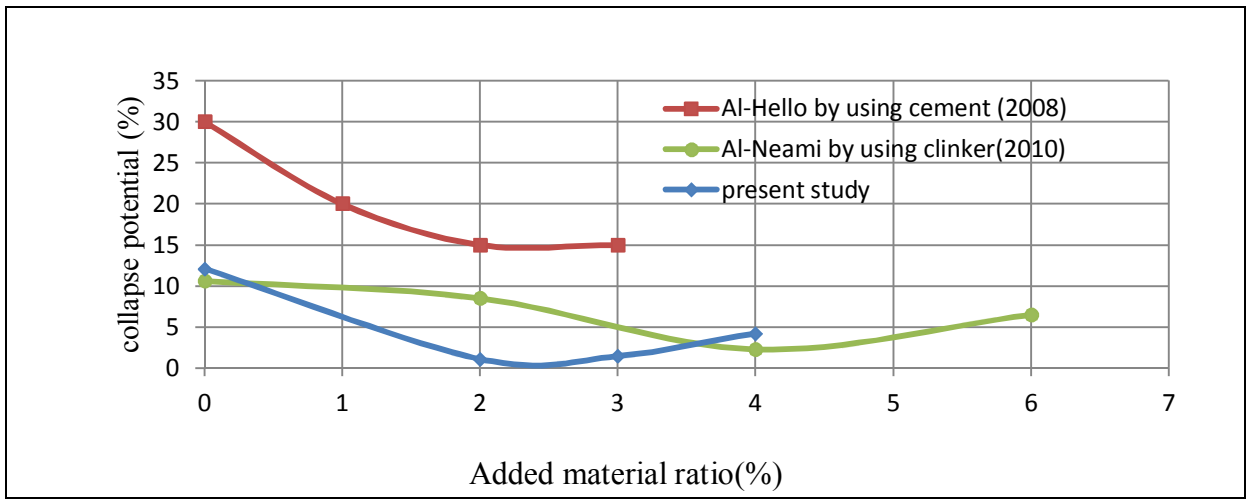

Fig .13 The relation between the clinker and cement and collapsibility and cement mixture of 10% by volume after seven days.

Its also used the Surfer (V 10) to draw the surface levels of the treated soil with curing time of the cement **Fig.14** to **Fig.19** .The surfer maps show that the settlement of the soil increasing with curing time and it focus at the starting portion and the end portion of the treated soil and at

the sides of the treated soil that's belong to broken parts of layers of cement in these portions which help the water to inflitrate into the soil esaliy as shown in **Fig.20** . Its also show that the levels of soil various due to the various of water cement ratio.

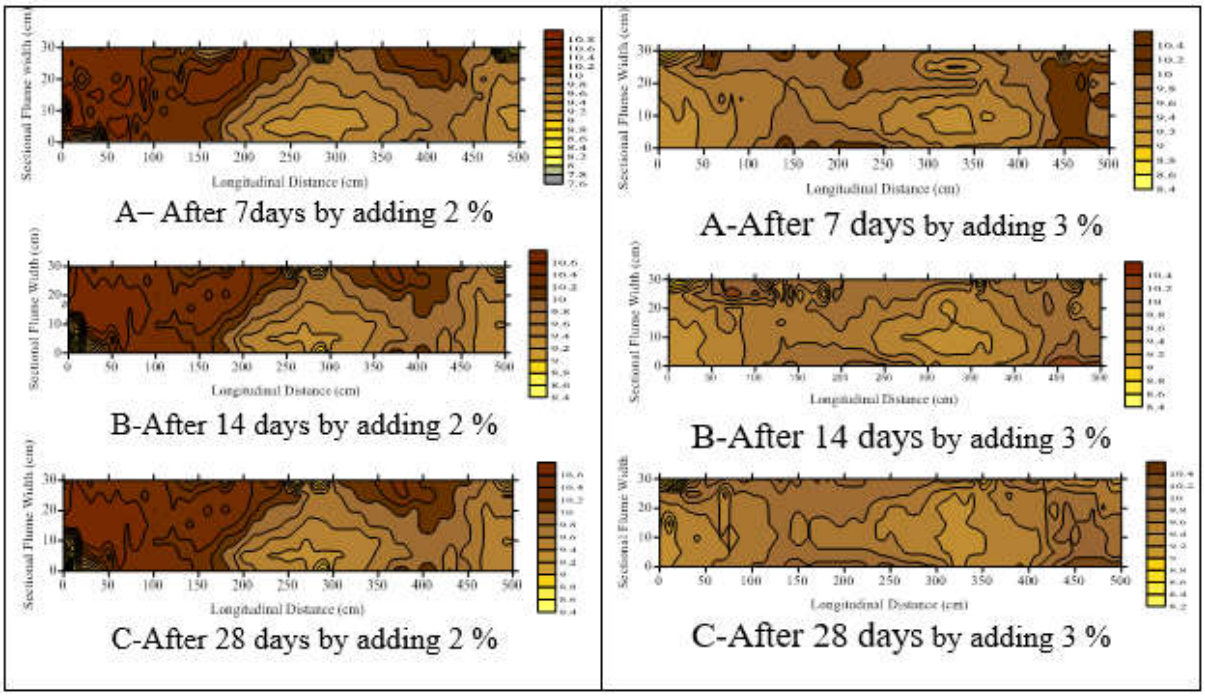

Fig .15 The contour maps for surface levels of the cladding soil with cement with 5% by volume and water/cement 2 % with time with maximum level of the soil (10.8) before starting taking the reading for cm and water/cement 3 % with time with maximum level of the soil (10.4) cm before starting taking the reading.

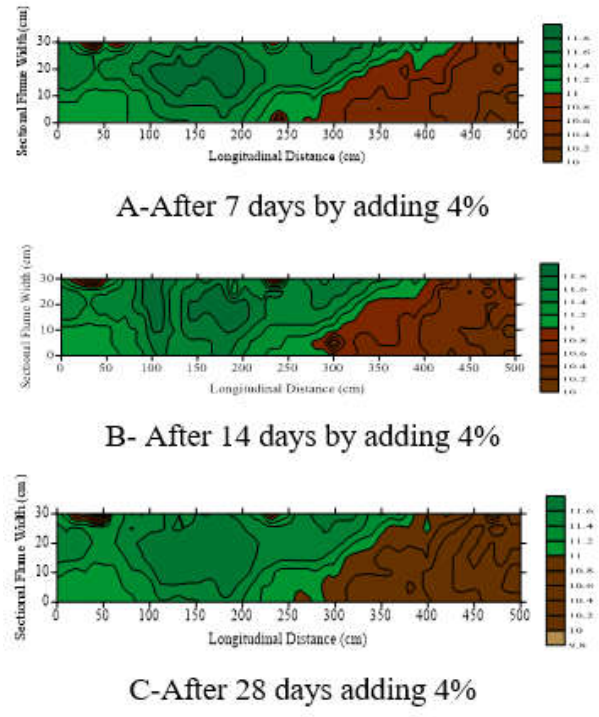

Fig .16 The contour maps for surface levels of the cladding soil with cement with volume 5% and water/cement 4 % with time with maximum level of the soil (11.8) cm before starting taking the reading.

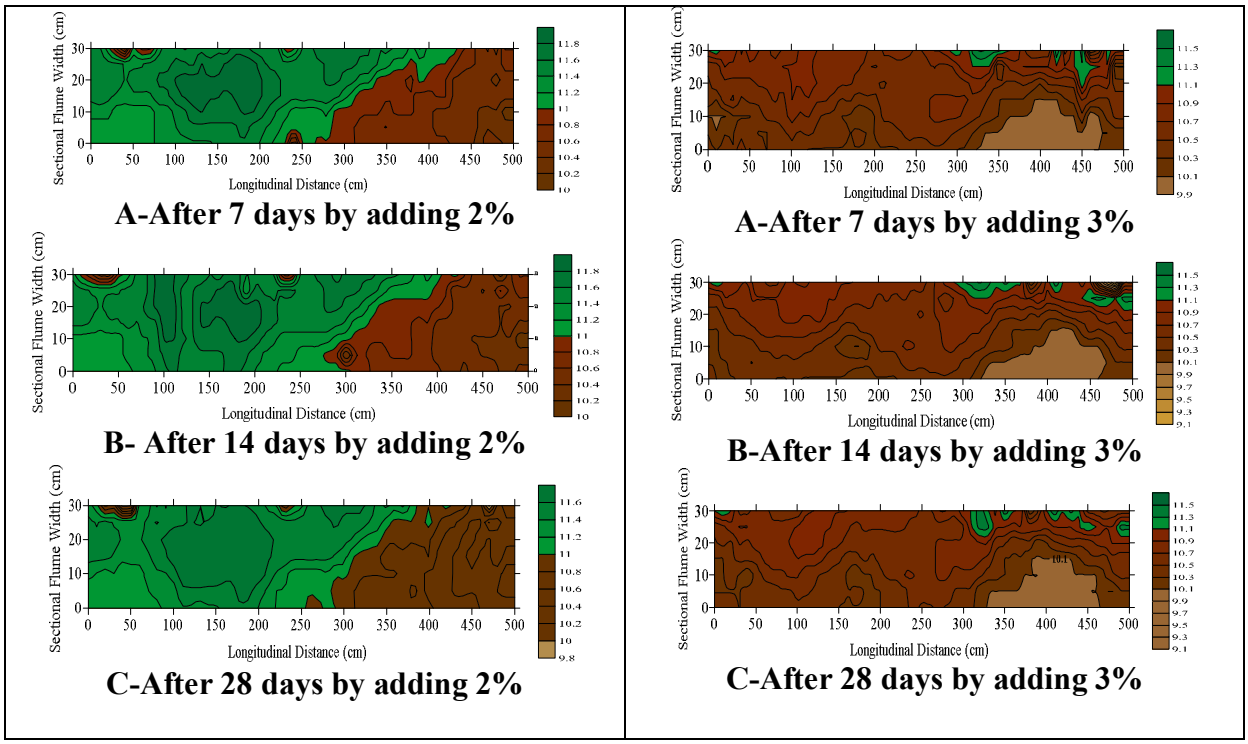

Fig .17 the contour maps for surface levels of the cladding soil with cement with volume 10% and water/cement 2 % with time with maximum level of the soil (11.8) cm before starting taking the reading and water/cement 3 % with maximum level of the soil (11.6) cm before starting taking the reading.

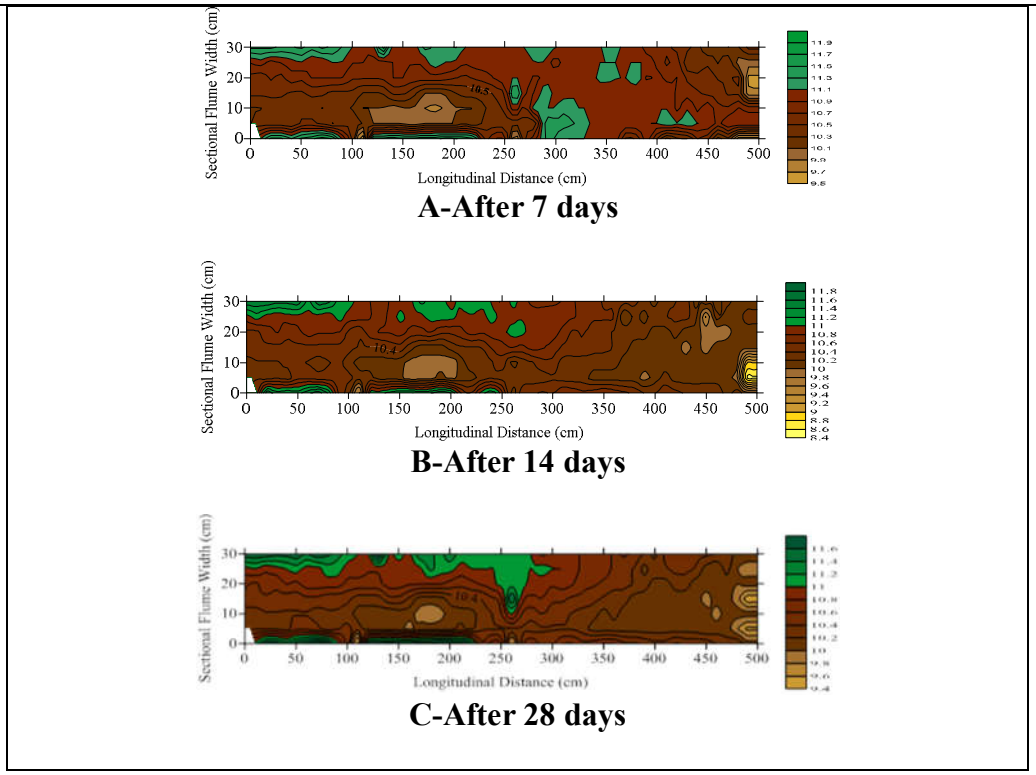

Fig .18 the contour maps for surface levels of the cladding soil with cement with volume 10% with water/cement 4 % with time with maximum level of the soil (11.9) cm before starting taking the reading.

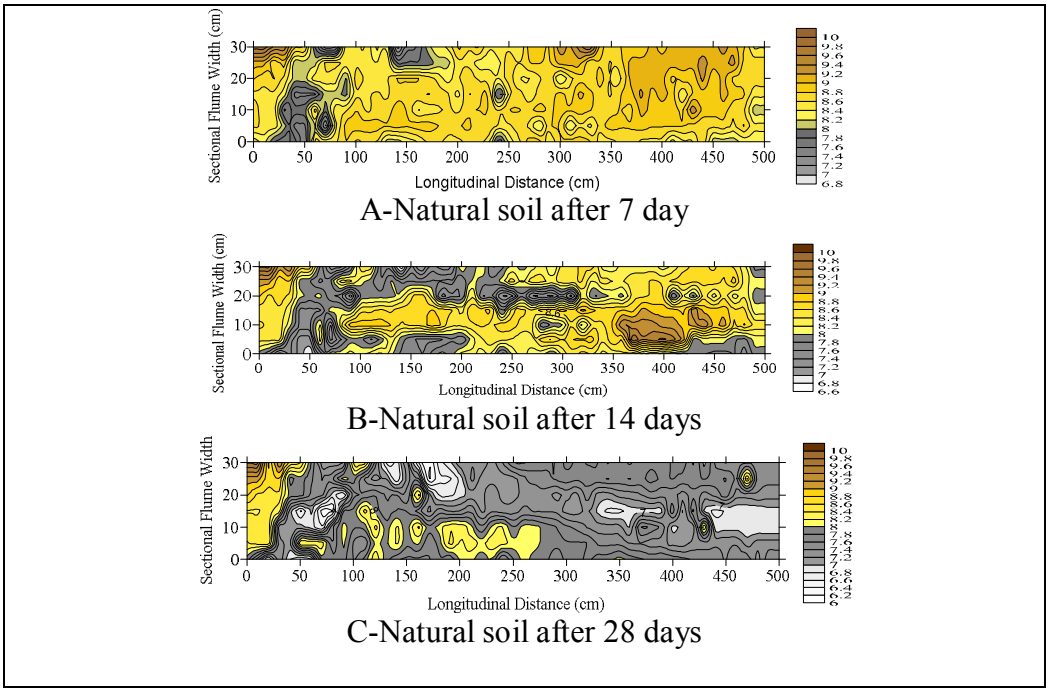

Fig .19 shows the contour maps for surface levels of natural soil with maximum levels 10 cm before starting take the reading.

Fig .20 Broken sides of the layer treated by using 10%by volume of cement

Conclusions

The fconclusions below can be draw according to results of the present study,:

1- The sandy gypseous soil treated by volume of cement with water cement ratio of 5 % and 10% of 2,3% of represented the optimum percentage which gives more advantage comparing with 4% of water to cement which used in this research.

2- The comparison between the treated soil with applied Portland cement in his study which show that the treatment by adding 2,3% of cement reduce the collapsibility to 50% while other study where use of clinker treatment the adding of 4% show the best reduce of the collapsibility about 78.46% and the cement method applied in this research and show that the cement treatment of adding 5% of cemnet by volume with water to cement ratio of 2% show the best reduce of the collapsibility about 91% while the volume of 10% give reduce of collapsibility about 90% but this method not workable because the layer of cement is broken by increasing the ratio of cement .

3- In present research the flume used with flow in all the direction with compared of all the research applied which applied consolidation cell only with static load in all directions.

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تحسين القنوات الترابية التي تم إنشاؤها على التربة الجبسية بواسطة السمنت

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الخلاصة

التربة الجبسية هي تربة انهيارية (تربة ذات مشاكل)، تتحمل الأحمال الثقيلة في حالة المحتوى المائي الطبيعي ولكن مع زيادة محتوى الماء، تعاني انخفاض كبير في حجمها والذي يعود إلى انحلال المحتوى الجبسي . العديد من الابحاث اجريت للتحري عن تصرف هذه الترب كل هذه الاعمال حددت ان استخدام الاضافات الهطول وتعرية الترب بشكل ملحوظ .

يقدم هذا البحث النتائج المختبرية للتربة المعالجة. تم جلب التربة من محافظة كربلاء بمحتوى جبسي(42.55 %). العديد من الفحوصات اجريت على التربة المعالجة وغير المعالجة وبنسب مختلفة من السمنت الى الماء مع زمن انضاج مختلف بتحديد افضل نسبة سمنت الى الماء مع اقل زمن انضاج والذي سيقلل الانهيارية للقناة الترابية ذات التربة الجبسية . تم استخدام نسبتين حجميتين (5, 10)% وبنسبه سمنت الى الماء(W/C) (4,3,2) ضمن الخليط , ثم رش الخليط على التربة المرصوصة. اوضحت النتائج انه باستخدام 2% من نسبة السمنت الى الماء لكلتا النسبتين الحجميتين (5, 10) % فان الانهيارية تقل بشكل ملحوظ مع زمن انضاج 14 يوم .

الكلمات المفتاحية :التربة الجبسية, الانهيارية ،نسبة الماء الى السمنت ،زمن الانضاج