The Effect of Sulphate Salts on The Collapsibility of Gypseous Soil

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Abstract

The research aims to study the presence effect of sulphate salts of (Calcium, Magnesium, and Sodium) in the ground water on the collapsibility of Kerbala gypseous soil with high gypsum content (27%). These types of salts are one of the main sources for ground water to be more salty.

The recompacted soil samples at field unit weight (13.51 kN/m^3) were prepared for each collapse test. Four different concentrations for each type of sulphate salts were added in each collapse test in addition to distilled water to predict the collapse potential for the gypseous soil. The soil sample soaked with distilled water only was denominated as the reference soil sample.

The results showed that the presence of magnesium sulphate salt (higher concentration of sulphate common ion for its high solubility) depressed the gypsum solubility in the soil and had been achieved minimum value of C.P% as compared with the other used solution.

تاثير الاملاح الكبريتية على انهيارية الترب الجبسية

الخلاصة

يهدف البحث الى دراسة تاثير الاملاح الكبريتية لل ـ (مغنسيوم ، صوديوم ، والكالسيوم) الموجودة في المياه الجوفية على انهيارية التربة الجبسية لكربلاء بمحتوى جبسي عالي (٢٧%). هذه الانواع من الاملاح الكبريتية هي احد المصادر الرئيسية لزيادة ملوحة المياه الجوفية. العينات المعاد رصها حسب الكثافة الحقلية (١٣,٥١) كيلونيوتن/م^٣ هيئت لكل فحص من فحوصات ايجاد معامل الانهيار،حيث تم تحضيراربع تراكيز لكل ملح من الاملاح الكبريتية اضافة الى الماء المقطر و اضافتها في كل فحص . العينة المغمورة بالماء المقطر فقط تم اعتبارها كعينة مرجعية للمقارنة مع بقية المحاليل الكبريتية.

النتائج اظهرت انه بوجود ملح كبريتات المغنسيوم في المياه الجوفية (تركيز عالي لايون الكبريتات الشائع نتيجة لذوبانيته العالية) يقلل من ذوبان الجبس في التربة وهذا بدوره يحقق اقل مقدار لمعامل الانهيار بالمقارنة مع بقية المحاليل المستخدمة.

1-Introduction

The term " collapsible soil " refers to any unsaturated soil that exhibits through a radical rearrangement of particles associated with a drastic loss in strength upon wetting with or without additional loading, [5]. This process which is often called " hydrocompression " or " hydro collapse " accompanied by rearrangement of solid particles to a closer state of packing and generating the collapsible settlement, [6].

The gypseous soil are considered one type of collapsible soils. This is due to the fact that the gypsum present between the soil particles provides an apparent cementation in the form of bonds that tightened the soil particles together, upon wetting these bonds are lost gradually leading to the collapse phenomenon.

Gypsum is a slightly soluble salt with solubility of 2 gm per liter in pure water at 20 c°, its solubility is affected by the temperature, stress level, nature and type of gypsum and the presence of other salts [1].

Investigations proved that most of projects were constructed upon gypsum stratum or soil containing excessive amount of gypsum, the drop in strength and settlement happened in case of soaking and ground water seepage to buildings foundations.

Accordingly, it is very important to study the effect of sulphates salts of the ground water on the collapsibility of Kerbala gypseous soils.

2- Material Used

2-1 Soil

The soil used in this paper was a gypseous soil (secondary gypsum), which was brought from zone 10 km from Al-Razaza lake behind the strategical way near Kerbala Thermstone Factory about 200m.The soil was taken from (2 - 2.5)m depth with a gypsum content of 27%, which represents highly gypseous soil, [2].

2-2 Soaking Solutions

2-2-1 Distilled Water : Distilled water was used in all tests .

2-2-2 Sulphates Solutions

The concentration of each sulphate salt was obtained from the same soil region and after (Al-Bassam and Al – Bidaree) results, [13]. Each sulphate salt was dissolved in distilled water to obtain the specific concentration for each type of salt in ppm. Four different concentrations for each sulphate salt (min., max. & between them) were prepared in order to simulate the field conditions of lowering and raising the salts concentrations of the ground water for futuristic changes.

3-Soil Testing

3-1 Physical and Chemical Tests

These tests were performed on Kerbala gypseous soil, see Fig.(1) and tables (1), (2) .

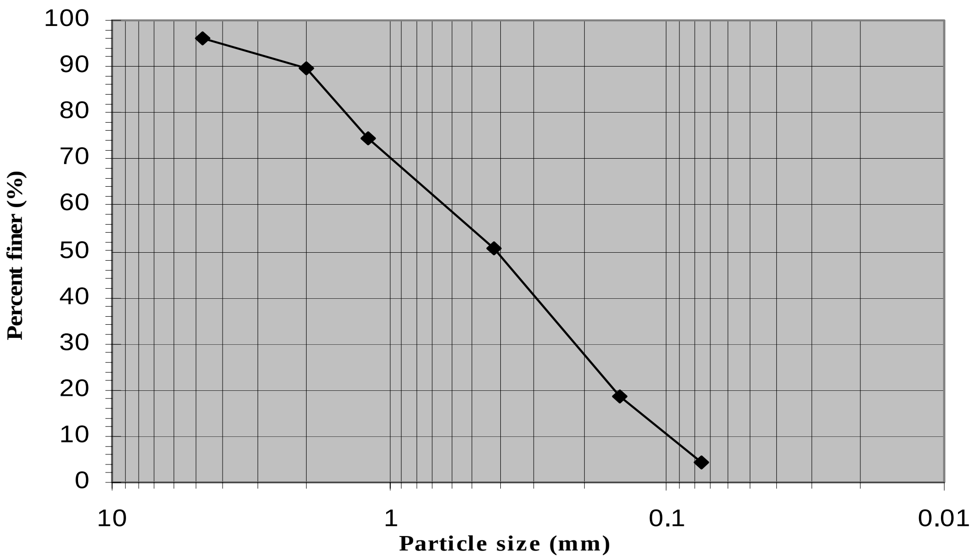

Fig.(1) Grain size distribution by kerosine method

Table (1) Results of physical tests

Test Type	Value	Specification
Particle size distribution (Kerosine treated method)	Classified SP	BS 1377:1975, test No.7(A), Head,1980
Specific gravity (Kerosine method)	2.45	BS 1377:1975, test No.6(B), Head,1980
Field unit weight(kN/m^3)	13.51	----------
Maximum dry unit weight(kN/m^3)	18.8	BS 1377:1975, section 3.7.3, Head,1980
Minimum dry unit weight(kN/m^3)	11.3	BS 1377:1975, section 3.7.4, Head,1980
Relative Density (%)	41	----------
Initial voids ratio (e_o)	0.853	----------
Moisture content (%)	2.2	ASTM (D2216-80)

Table(2) Results of chemical tests
(After Geological survey and mining company)
(Atomic Absorption)

CaO %	MgO%	SO_3%	Na_2O%	CO_3%
9.53	0.62	13.76	0.54	0.12

3-2 Collapsibility Test

Single odeometer tests were performed as suggested by, [9], the soil samples with 50mm diameter and 19mm thickness. This method is similar to the standard odeometer test except that the porous stones were dry as well as the specimens. The stresses were doubled every 24 hrs up to the desired stress (200 kPa),where distilled water or sulphate solutions were added and collapse if any , took place. The vertical deformation of the specimen was recorded at intervals until either equilibrium was reached or a duration of 14 days elapsed, whichever was reached first. Then the C.P was calculated according to the procedure recommended by [8].

C.P = $\Delta e/ (1+e_o)$

C.P = Collapse Potential

Δe= change in voids ratio upon wetting

e_o= Initial voids ratio

Finally, it should be stated that in all types of tests performed a seating load 1kPa was used at the beginning of each test to ensure elimination of any gaps between the specimen and the porous stones or the confining ring, [10].

4- Results and Discussion

4-1 Log Stress – Void Ratio Relation

From fig.(2) to (4), it is obvious that samples soaked with distilled water revealed a large change in void ratio (higher C.P) upon wetting as compared with the other sulphates salts solutions which reflect the collapsibility behavior of gypseous soil.

4-2 Stress – Collapse Potential Relation

During soaking two process contributed in soil compression, the first process is physical effect which means reducing the spacing between soil particles and reorientation of them due to low soil field density 13.51 kN/m^3. The second process was the chemical effect which means the dissolution of gypsum present in the soil and hence reducing the soil pore spaces.

The gypsum $CaSO_4.2H_2O$ is considered sparingly soluble salts, its solubility in pure water (2gm/l) while the solubility of $MgSO_4.7H_2O$ and $Na_2SO_4.10H_2O$ are (250 gm/l) and (190 gm/l) at 20C°, respectively, [11],thus the common ions (SO_4^{-2}, Ca^{+2}) for Calcium sulfate solution are so less as compared with (SO_4^{-2}) common ion of Sodium and Magnesium sulphate solutions, as a result the gypsum solubility of the soil phase in distilled water and calcium sulphate solutions are higher than the other sulphate salts solutions.

It can be concluded that the presence of more soluble salts may supply common ions to the soil solution and hence depress the solubility of the solid gypsum phase in the soil but its solubility increases with presence of other salts without common ions. [12], and [4], and according to (Le –Chatelier law), " increasing substance concentration in one side of reaction leads to move the equilibrium to other reaction side to reduce its concentration", [14].

$$CaSO_4.2H_2O \rightleftharpoons Ca^{+2} + SO_4^{-2} + 2H_2O$$

This behavior reflects the increasing of collapse potential (C.P) %, ranging from maximum to minimum concentration for each salt as(3.24 – 7.81) %, (4.1 – 9.5) %, and (5.1 – 12)% for sulphate solutions of (Mg^{+2}, Na^{+1}, Ca^{+2}) simultaneously, and revealed a higher C.P of (14.5)% for distilled water only see Fig. (5) to (7).These tests were achieved at a temperature ranging from (19-22)C˚.

5- Conclusions

1-Thegypsum solubility of the soil phase decreases in the presence of more soluble salts in the ground water which have common ions, but increases in the presence sparingly soluble salts(low solubility salts) .

2-The presence of calcium sulphate salts in the ground water (lower concentration of sulphate common ions for its low solubility) revealed a higher collapse potential as compared with sulphate salts of (sodium, and magnesium), respectively.

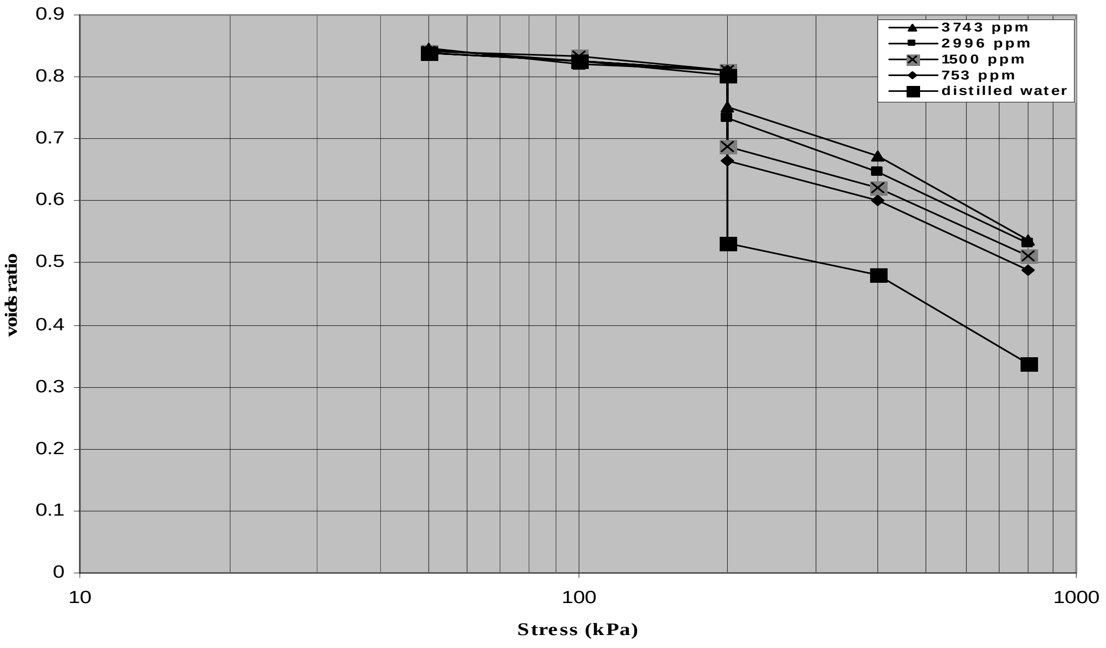

Fig. (2) Stress–voids ratio relation for magnesium sulphate solution and distilled water

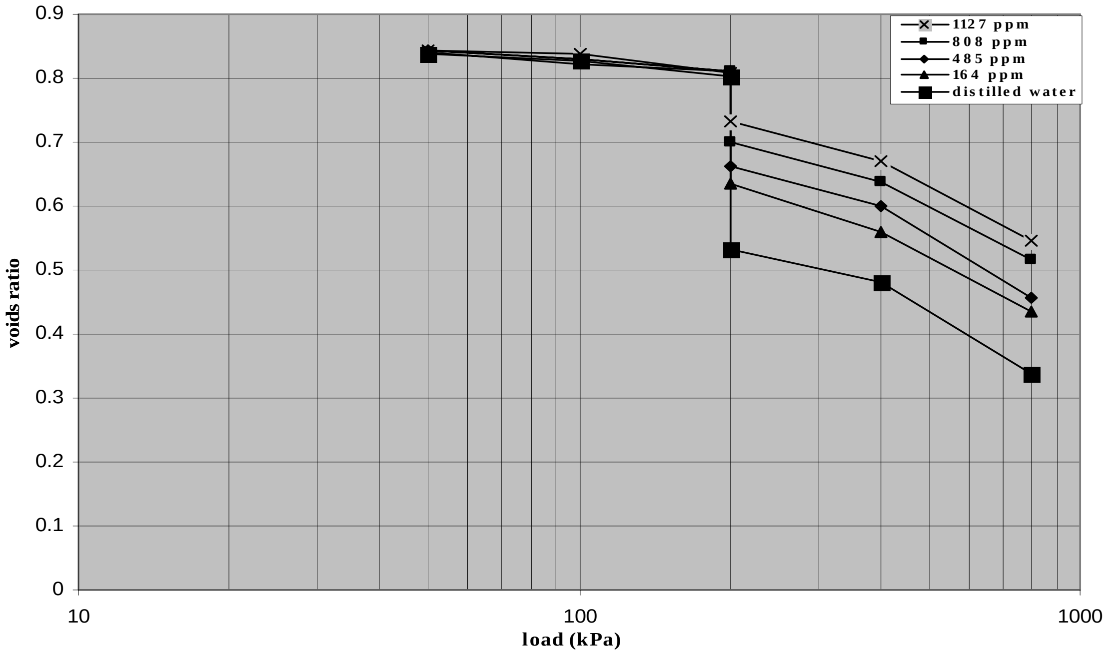

Fig. (3) Stress–voids ratio relation for sodium sulphate solution and distilled water

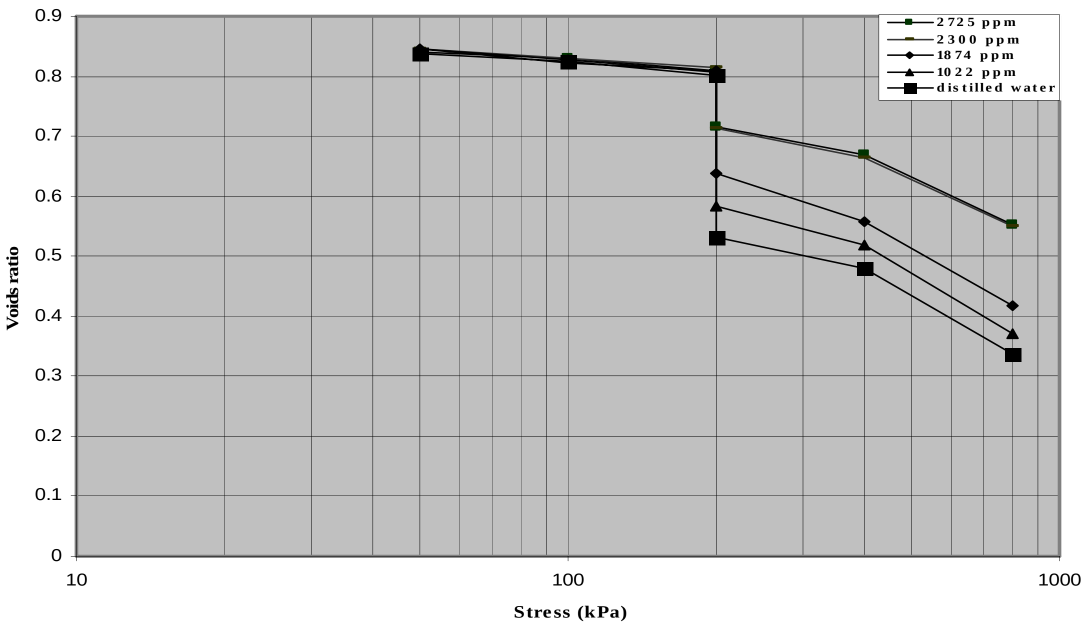

Fig. (4) Stress–voids ratio relation for calcium sulphate solution and distilled water

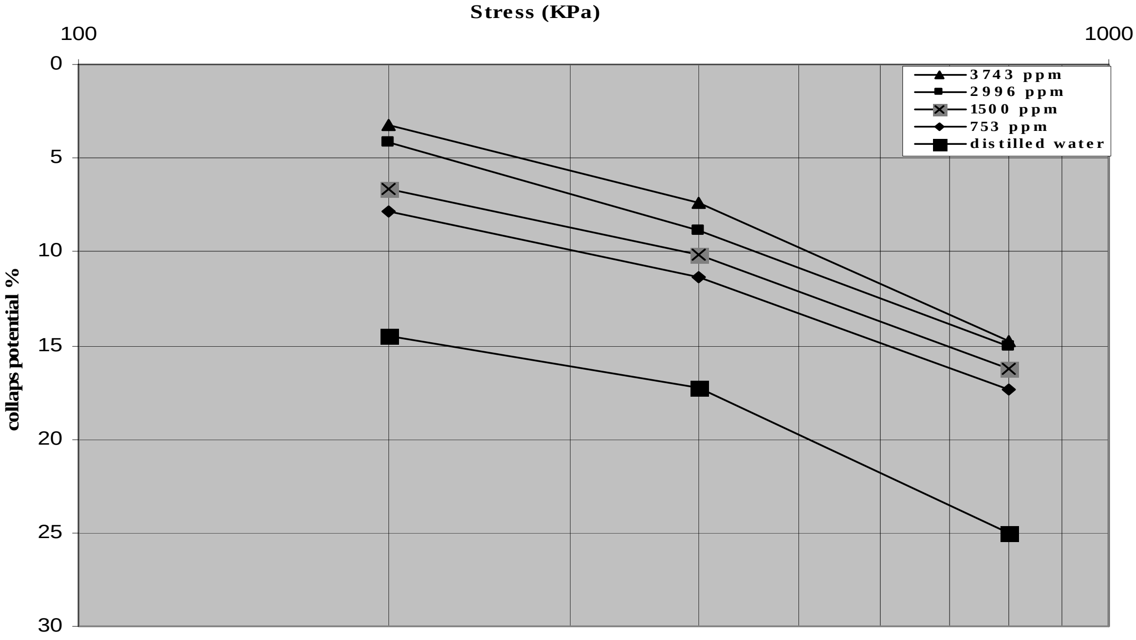

Fig. (5) Stress–collapse potential relation for magnesium sulphate solution and distilled water

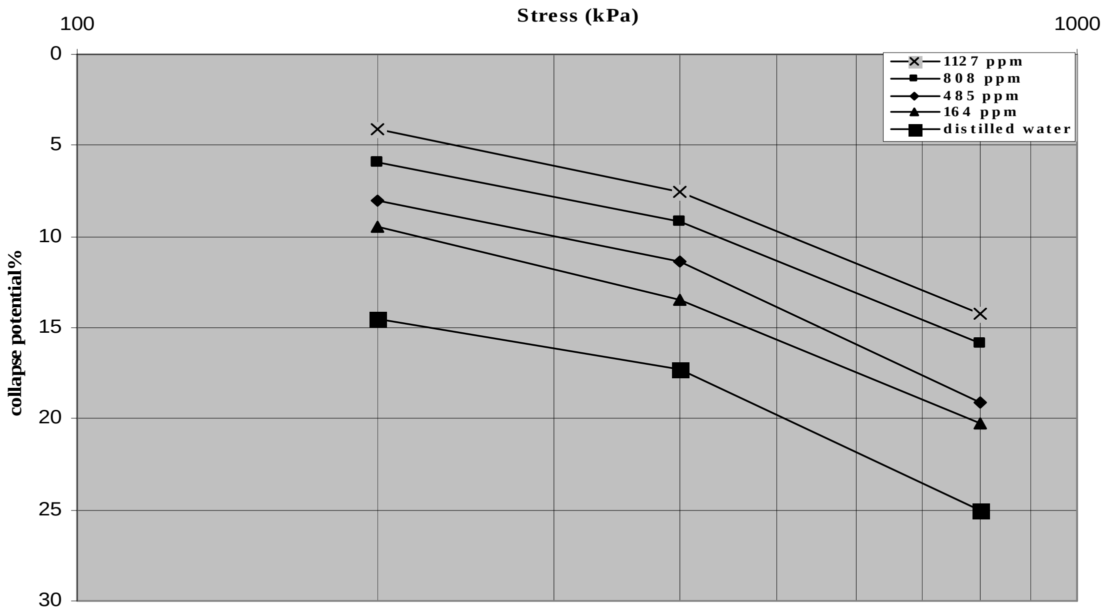

Fig.(6) Stress–collapse potential relation for sodium sulphate solution and distilled water

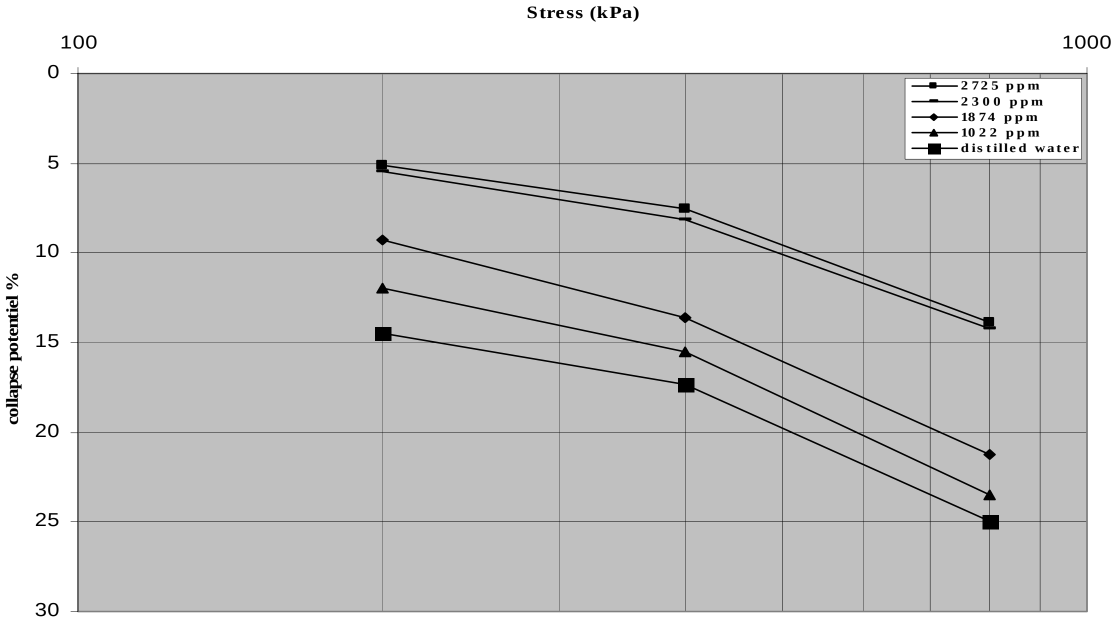

Fig. (7) Stress–collapse potential relation for calcium sulphate solution and distilled water

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