Improvement Of Sandy Soil Properties By Using Bentonite

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ABSTRACT

The main goal of this study is studying the improvement the engineering properties of soil mass. These properties are shear strength and maximum dry density which are effect on the foundations of the structures and their stability. The cohesionless soil can be given some cohesion by rearrangement of soil particles and decrease the voids between the particles by adding fine particles between them and decrease voids and increase the density, then the required properties can be improved. the chemical combinations due to the additives can also generate new bonded materials give the soil mass a good properties. In this study, the effect of different percentages of Bentonite which were added to the soil on the engineering properties of soil. The grain size distribution of soil sample and the classification of soil was (sandy poorly graded) according to the Unified Soil Classification. The compaction test was made for (2.5, 5, 7.5, 10)% of Bentonite. The direct shear test was made on the soil sample also for the same percentages and the shear strength parameters (C & Ø) were changed. Adding 7.5% of Bentonite to the poorly graded sandy soil gives better results than other percentages used in the present study.

المستخلص

أن الهدف الأساسي من هذا البحث هو دراسة تحسين الخواص الهندسية لكتلة التربة ومنها زيادة مقاومة القص وزيادة الكثافة الجافة العظمى وهما من الخواص ذات التأثير الكبير على أسس المنشات الهندسية حيث يكون تأثيرها واضح في تصميم أسس هذه المنشات وأستقراريتها، إن الترب غير المتماسكة يمكن أعطائها قوة تماسك بدرجة معينة من خلال أعادة ترتيب حبيبات التربة وتقليل الفجوات بين تلك الحبيبات حيث تشغل دقائق المضاف الحيز الموجود بين حبيبات التربة فتقل الفجوات الموجودة وبالتالي تزداد كثافة التربة ويمكن أن تتحسن خواصها المطلوبة ،كما أن التفاعل الحاصل بين مركبات التربة والمضاف(أذا توفرت ظروف التفاعل) يؤدي إلى تكوين مركبات أخرى قد تكون أكثر قوة من المركبات الأصلية بالتالي يمكن الحصول على خواص جيدة . في هذه الدراسة تتم مقارنة تأثير نسب مختلفة من المادة المضافة على الخواص المطلوبة وبالتالي اختيار أفضل نسبة من حيث الموازنة بين درجة التحسين التي قد تعطيها هذه النسبة من المضاف ومقدار هذه النسبة . تم إجراء فحص التحليل المنخلي لعينة التربة المختارة حيث على أساسه تم تصنيف التربة وكانت من نوع (sandy poorly graded)، وكذلك تم إجراء فحص الرص لعدة نسب مختلفة من البنتونايت (2.5 ، 5 ، 7.5 ،10) % ولوحظ تحسن (ازدياد) في الكثافة الجافة العظمى بالتدرج وصولا إلى نسبة 7.5 % .وبعد ذلك تم إجراء فحص القص المباشر لنفس النسب المذكورة من البنتونايت ولوحظ تغير في معاملات القص حيث زادت قيمة معامل التماسك (C) بازدياد النسب وكذلك قلت قيمة زاوية الأحتكاك الداخلي (Ø) ولكن بمقدار قليل جدا .

LIST OF SYMBOLES:-

Symbol	Title
C	Cohesion
Ø	Angle of internal friction
D_{10}, D_{30}, D_{60}	Diameter of particles finer than (10,30,60)% respectively
C_U	Coefficient of uniformity
C_c	Coefficient of curvature
ρ, γ	Bulk density and unit weight of soil respectively
g	Gravitational constant
w	Moisture or water content
M_s	Mass of solid particles of soil
M_t	Total mass of solids
V_t	Total volume of soil
N	Normal force

1. INTRODUCTION

1.1 Bentonite

Bentonite is the name given to the practical form of the clay mineral Monotmorillonite. Most Bentonite deposits are formed by the alteration of volcanic ash, mainly in damp or wet conditions, or by decomposition of primary rocks in water. The color of Bentonite deposits varies and may be white, yellow, blue, brown, yellow-green, etc., according to location. The name is derived from the Front Benton rock deposits in Wyoming where large deposits of natural sodium Bentonite were reported in 1896 and found wide application in the oil-well drilling industry from about 1929. (Hutchinson, Daw, Shotton and James (1975)).

1.2 Soil classification

Soil classification enables the engineer to assign a soil to one of limited number of groups, based on the material properties and characteristics of the soil. The classification groups are then used as a system of reference for soils. Soil can be classified in the field or in the laboratory. Field technique is usually based upon visual recognition. Laboratory technique include several specialized tests. In this work the (Unified Soil Classification) was adopted to classify the soil sample used in the present study. (G. N. Smith, (1998)).

1.3 Shear Strength of Soil

The property that enables a material to remain in equilibrium when its surface is not level is known as its shear strength. Soils in liquid form have virtually no shear strengths of relatively small magnitudes compared with those exhibited by steel or concrete. The direct shear test were used to find shear strength parameters of soil used in this work (C and Ø).

1.4 Compaction Test

In 1933, R. R. Proctor showed that the dry density of a soil obtained by a given compactive effort depends on the amount of moisture the soil contains during compaction. For a given soil and a given compactive effort, there is one moisture content called “optimum moisture content” that occurs in a maximum dry Density of the soil. Those moisture contents both greater and smaller than the optimum value will result in dry density less than the maximum. A typical compaction curve used by consultants is shown in figure (1) below. All geotechnical consultants are familiar with the Proctor Density procedure.

The test methods are also listed with ASTM. Essentially, Sixty years after Proctor, his testing procedures are still closely followed, with only minimal refinements. Most laboratories have used mechanical compaction devices to replace hand compaction. (Braja M. Das, (1997))

2. THE LABORATORY TESTS

Many laboratory tests were made to the soil sample which was taken from the site of al-Forat quarter in al-Najaf city. The tests without Bentonite and with Bentonite were made.

2.1 Tests on soil sample without Bentonite

1-Soil classification: in order to classify the soil sample the sieve analysis must be attended.

Sieve analysis test: this test was made for a sample of soil weighs 1000 gm after drying it in the oven to avoid the volume changes due to the moisture content, the set of sieves was used with openings (4.75 , 2 , 0.85 , 0.6 , 0.3 , 0.075)mm and pan in the lower of a set. The grain size distribution of the mechanical sieving operation for a period of 10 minutes is shown in fig. (1)

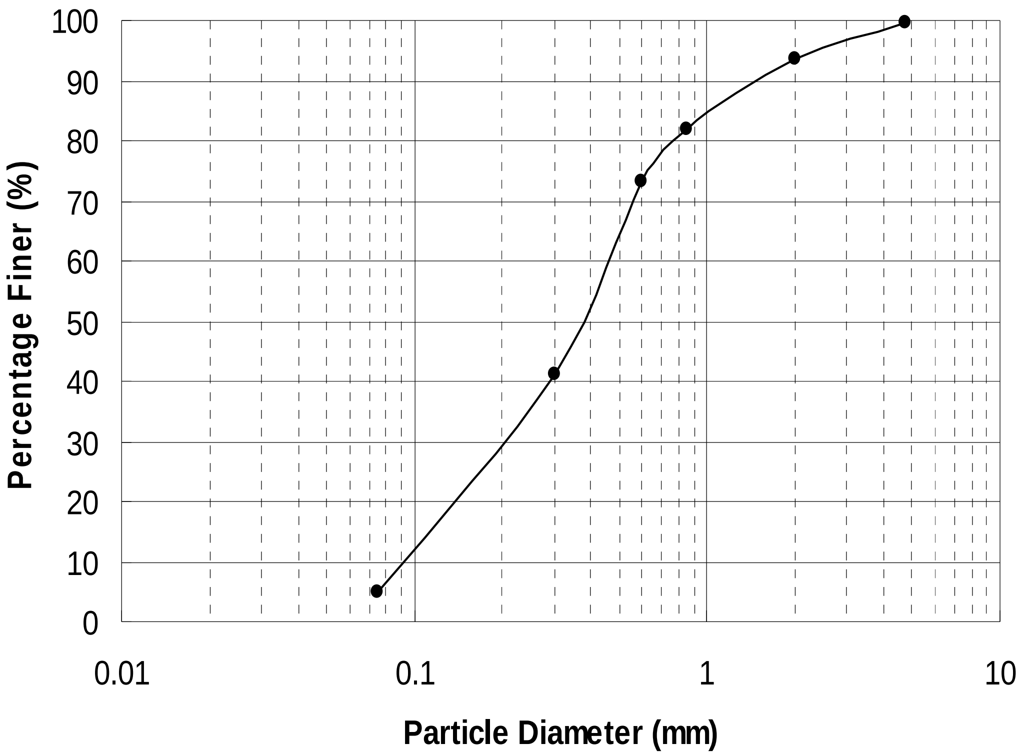

Fig.(1). Grain size distribution of a sample

In order to classify the sample, the following calculations depending on the grain size distribution above were made:

D_{60} = 0 .46 , D_{30} = 0.2 , D_{10} = 0.089

Then, C_U= 5.168 , C= 0.977

UNIFIED CLASSIFICATION SYSTEM

RETAIND ON NO.200 SIEVE = 100% - 5.88 % = 94.22 %>50%

COARSE – GRAIND SOLIDS

PASSES NO.4 SIEVE = 99.5%> 50%

$\longrightarrow$ SAND . $C_U = 5.168 < 6$

$C_c = 0.977 < 1$ $\longrightarrow$ **sp (sandy poorly graded)**

2-Modified Proctor test:

Unit Weight

The unit weight of the sample was calculated by using modified proctor test for the moisture ratio of (4 , 8 , 12 , 16)% from the weight of the sample and the relation between the dry unit weight and moisture content after test are shown in fig. (2) below. Maximum dry density was founded as 1.877 gm/cm^3, and optimum moisture content as 10.5 percent.

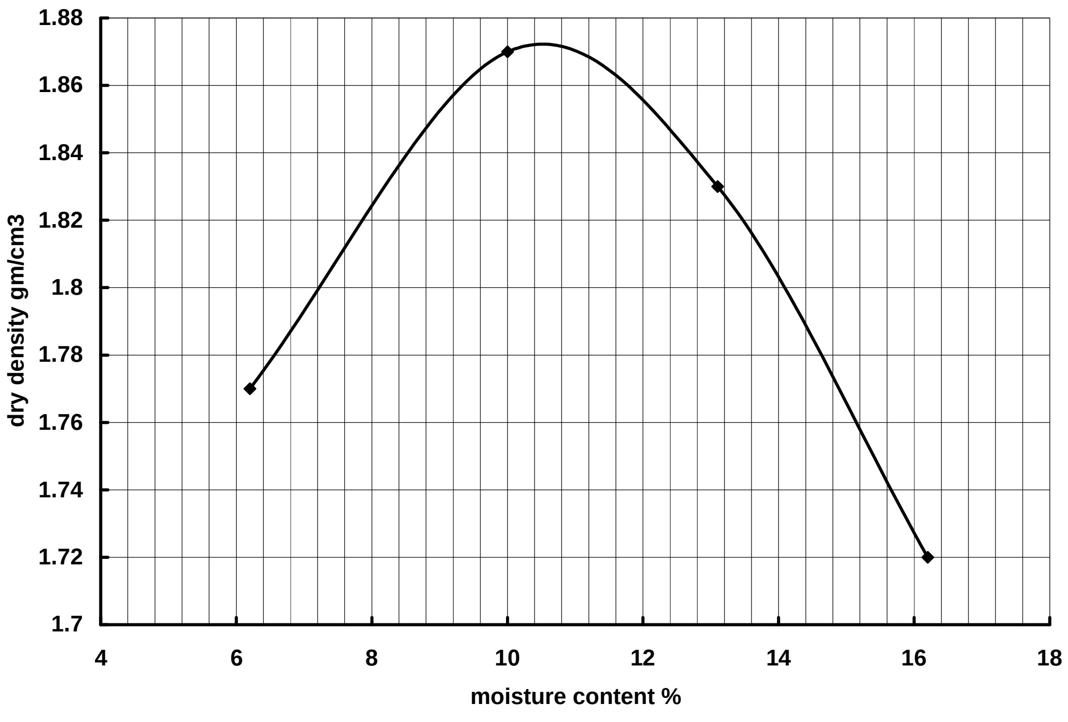

Fig.(2). Relationship between moisture content and dry density without Bentonite

3- Direct shear test:

The oldest form of shear test upon soil is the direct shear test. The direct shear device lacks a number of features that limit is applicability. For example, there is no way to control the confining pressure. Also, since there is no way to measure excess pore water pressures generated during shearing of saturated clay specimens, use of the direct shear test is generally limited to cohesionless soils or when the soil has a low cohesion such as the soil used in this work which is classified as a (sandy poorly graded). In the most cases computer plots a graph of the shearing force and strain as the test continuous. Failure of the soil is visually apparent from a turning point in the graph. Fig. (3) shows the direct shear test which was made on the soil sample without Bentonite. The peak point of shear stress failure are very clear.

Fig.(4) shows that the soil sample has a low value of cohesion due to the amount of the particles passes from sieve No.200, this value of cohesion can be observed from the intersection the line with the y-axis as :-

Y= 1.4096 X + 0.0689 ,At X=0.0 , Y= **6.89 kPa** which is represent the value of cohesion (**C**).

The value of angle of internal friction (**Ø**) can be founded from the slope of the line as:-

Derivative of Y = 1.4096 which is represent $\tan^{-1}$**Ø** **,** then the value of angle of internal friction **(Ø)** = **54.65**$^{\circ}$

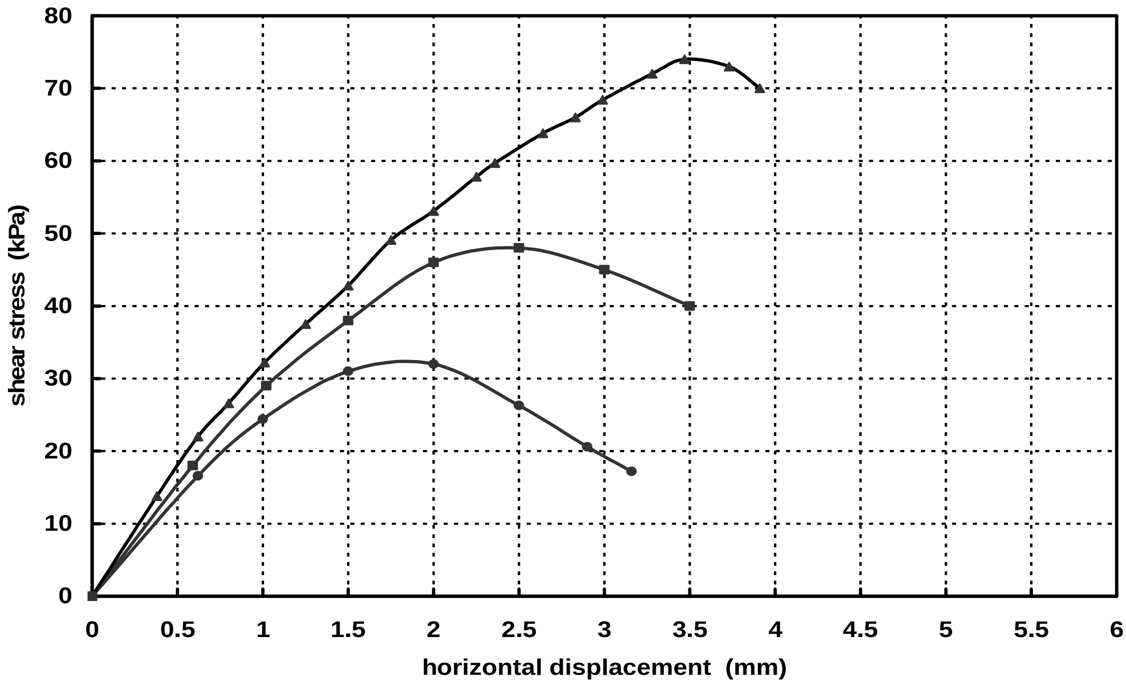

Fig.(3). Relationship between shear stress and horizontal displacement without Bentonite

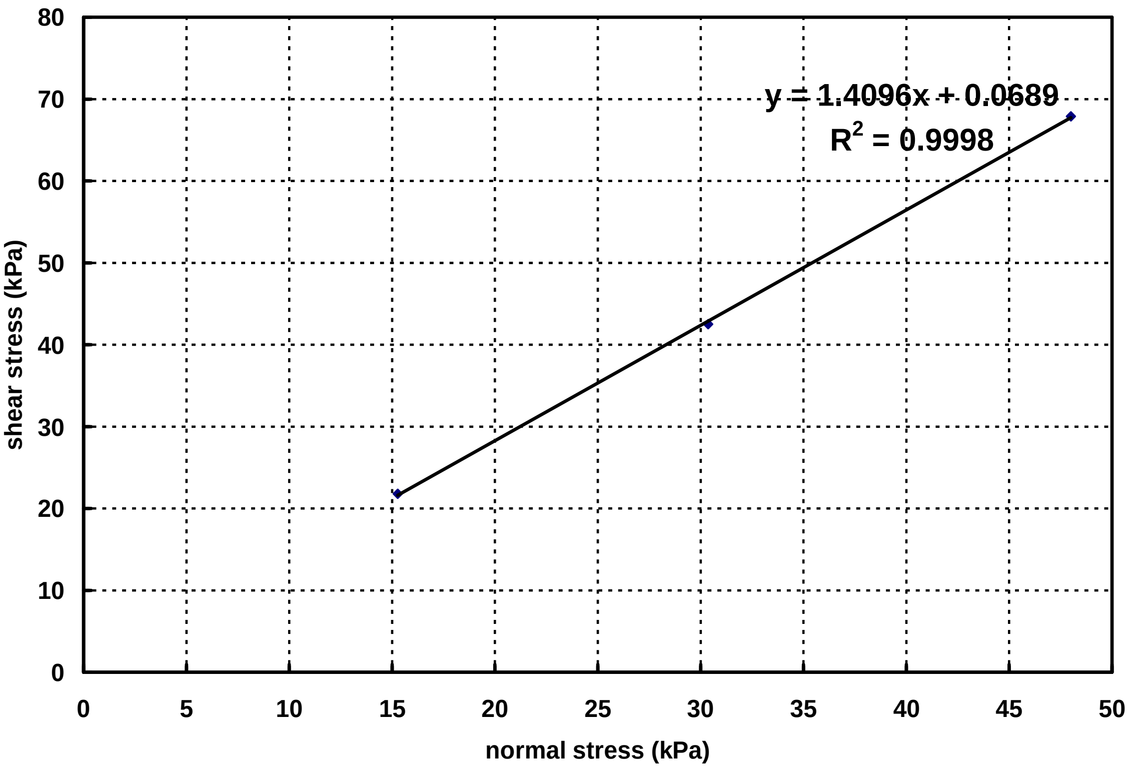

Fig.(4). Relationship between normal stress and shear stress without Bentonite

2.2 Tests on soil sample with Bentonite

In this part the tests were made for the soil sample with different percent of Bentonite to study the effect of using the Bentonite as an improving material for the soil which has a low density and low shear strength to adding more suitable properties to resist the load applied on the soil.

1-Modified Proctor test:

The modified proctor test was made on the sample with different percentages of Bentonite these percentages are (2.5, 5, 7.5,10

Fig.(5) shows the dry density and moisture content relationship for the above percentages of Bentonite as well as without Bentonite to recognize the difference in the dry density with and without Bentonite. From this figure can be seen also that the increasing in the Bentonite content as percent of soil mass increase the maximum dry density, then the soil can be more suitable to construct the structures on it. The increasing in dry density after 7.5% of Bentonite is very little, then can be say the percent 7.5 is the better percentages of Bentonite to be added to the poorly graded sand increase the dry density.

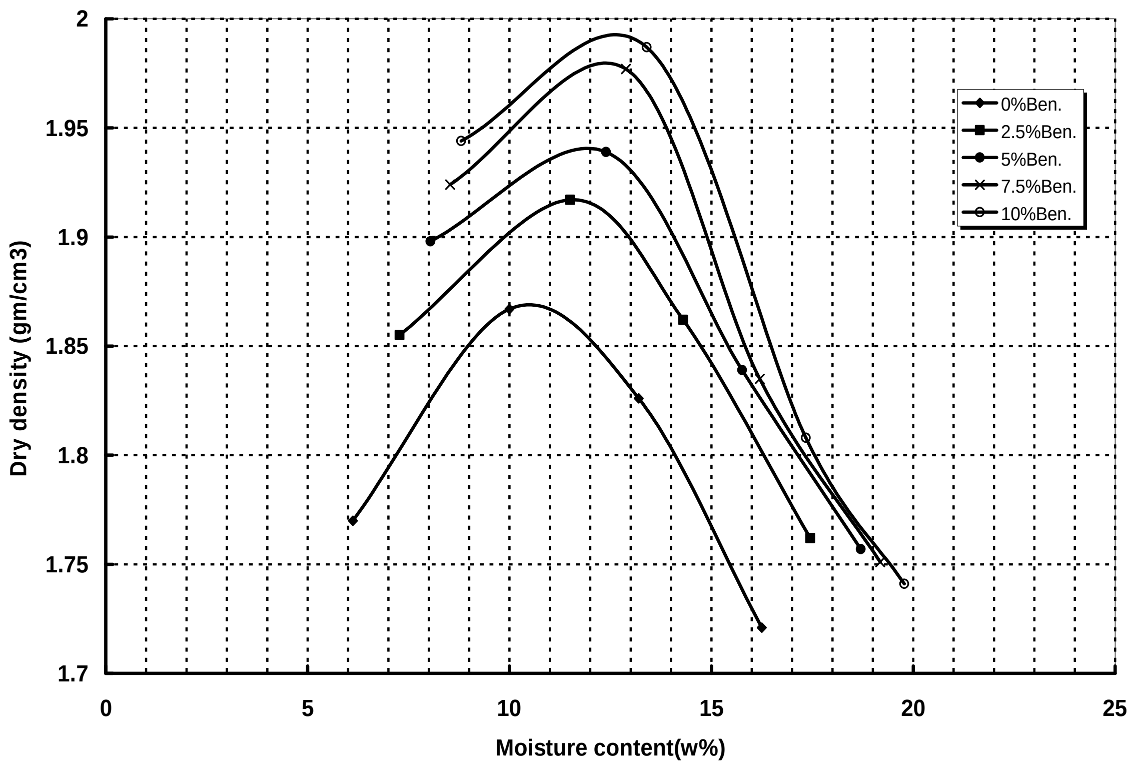

Fig.(5). Relationship between moisture content and dry density with and without Bentonite

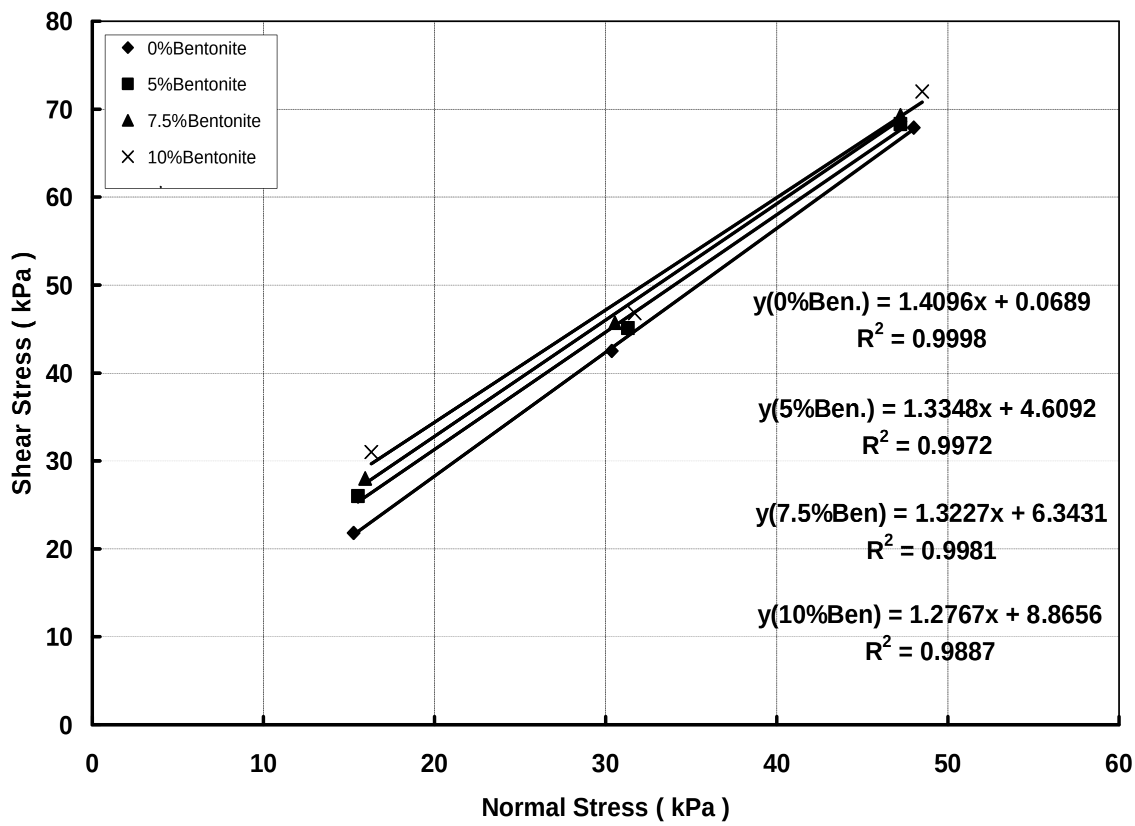

Fig.(6). Relationship between normal and shear stress with and without Bentonite

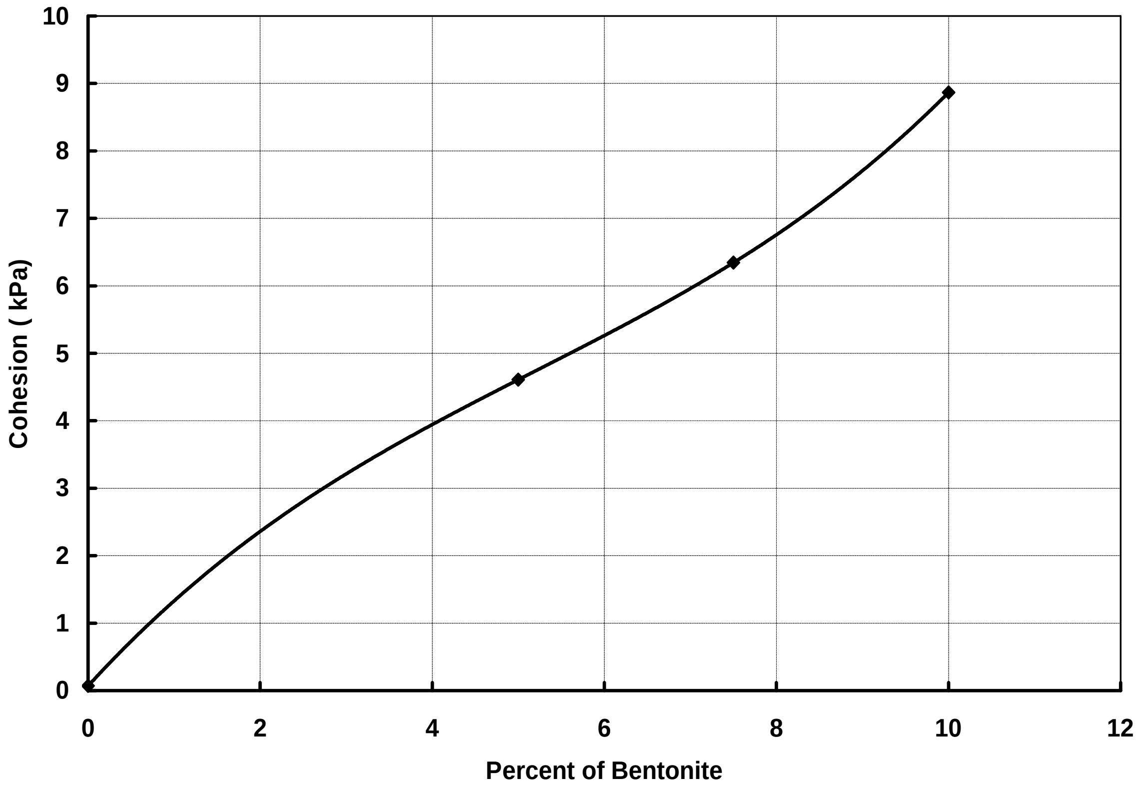

Fig.(7). Relationship between percent of Bentonite and cohesion

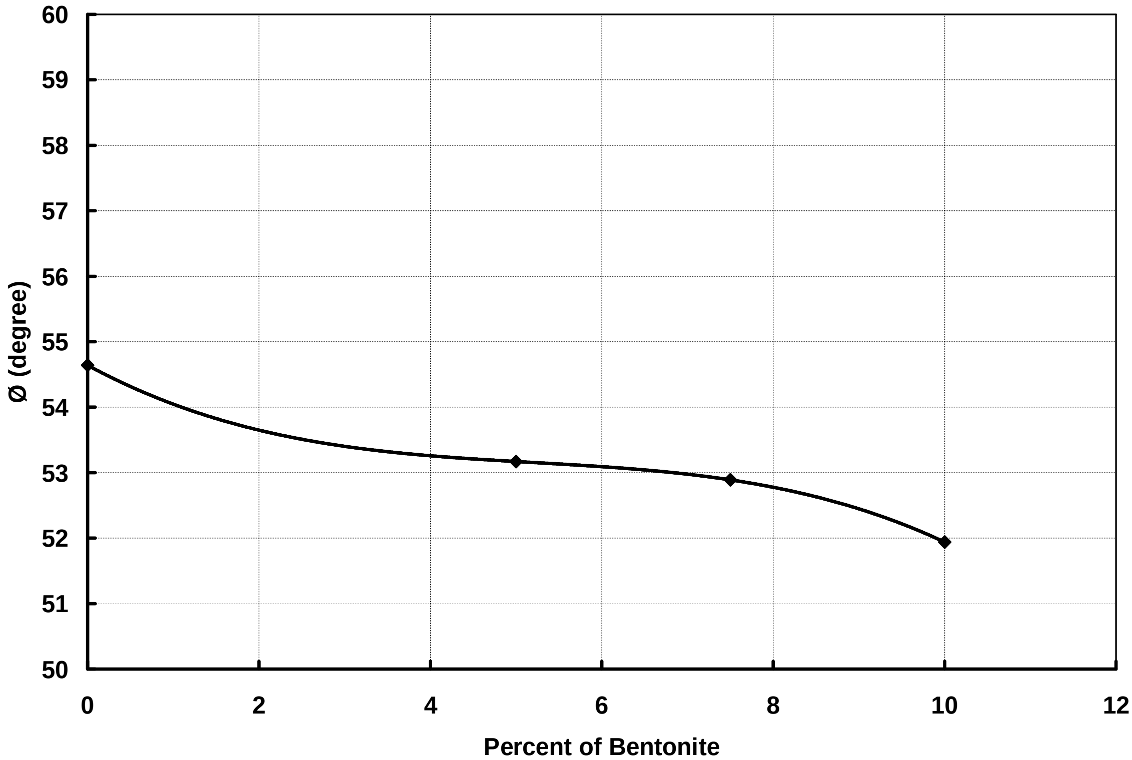

Fig.(8). Relationship between percent of Bentonite and angle of internal friction

From the results shown in fig.(6), can be concluded:
Increasing the percentages of Bentonite in the soil samples, the cohesion increases and the angle of internal friction decreases with a small amount, because the properties of Bentonite give the soil the behavior of clay minerals which are fill in the voids of sandy soil and increase the cohesion of soil.

Fig. (7) shows the relation between percentage of Bentonite and the cohesion of soil (C) relationship. Increasing in the cohesion due to the increase in Bentonite is very clear. Fig.(8) shows the relation between percentage of Bentonite and angle of internal friction. The difference in angle of internal friction (Ø) is very low after the percent of Bentonite 7.5%.
From these figures can be concluded that the ideal percent of Bentonite may be used is 7.5%.

CONCLUSIONS

1- The density or unit weight of the soil can be increased by the rearrangement of the soil particles by the mechanical effort using the compaction and fine soil particles such as Bentonite to fill the voids in the poorly graded sandy soil.
2- The cohesion of the sandy soil can be improved by using the Bentonite as a percentage of soil mass.
3- The plasticity of the soil can be improved by using the Bentonite.
4- The increasing in the percent of Bentonite from 2.5% to 7.5%, the cohesion (C) of soil increases.
5- The value of angle of internal friction (Ø) don't appear a real effect by increasing of Bentonite. (Ø) decrease with a small amount with increasing of Bentonite.
6- Adding 7.5% of Bentonite to the poorly graded sandy soil gives better results than other ratios used in the present study, i.e increasing (C) and decreasing (Ø).

REFERENCES

1- Braja M. Das, (1997), "**Advanced Soil Mechanics**", Second Edition, Taylor & Francis, U.S.A.
2- G. N. Smith, (1998), "**Elements of Soil Mechanics**", Seventh Edition, Blackwell Science Ltd.
3- Hutchinson, Daw, Shotton and James (1975), "**The Properties of Bentonite Slurries in Diaphram Walling and Their Control**", Institute of Civil Engineers, London.
4- Karl Terzaghi & Ralph B. Peck & Gholamreza Mersi, (1996), "**Soil Mechanics in Engineering Practice**", Third Edition, John Wiely & Sons. Inc. New York
5- Lamb A,T.W and whitman, R.v (1969), "**Soil Mechanics**" John Wiely & Sons. inc. New York.