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COHESIONLESS SOIL PROPERTIES IMPROVEMENT USING BENTONITE

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ABSTRACT

Construction of building structures on very weak or soft soil is considered as unstable and unsafe. Improvement of the soil strength may be tackled by different subgrade improvement methods or techniques; bentonite has been selected as the binding material which was used in the enhancement of the soil randomly at five different bentonite content, i.e. 3 %, 6 %, 9 %, 12% and 15% by weight of soil. The task of the present work is the strengthening or improvement of cohesionless soil engineering properties by using bentonite. The selected improved soil properties are maximum dry unit weight and shear strength which affects the bearing capacity of structure foundations and their stability. After improvement, cohesionless has gain some apparent cohesion by rearrangement of soil grains and decrease the voids between the grain and increase the density by adding fine grains and then the required properties can be improved. The soil grain size distribution and the unified soil classification system are used to distinguish the soil sample. The tested soil is classified or named as (sandy poorly graded) in this work. The experimental program consists of standard Proctor tests, and direct shear tests which were conducted on the cohesionless soil-bentonite mixtures to study their properties. Based on the result obtained, the short coming of this treatment is the increasing in maximum dry density and shear strength with acceptable amount. It is found that the 9 % of bentonite content is the optimum value which gives the better results obtained in this study.

Keywords: Bentonite, cohesionless, experimental, soil improvement.

1. INTRODUCTION

Civil engineering building constructions in the site with weak or soft soils are one of the major common problems that face the engineer. The stabilization soil means the development or improvement of one or more engineering properties of soils, through mechanical or chemical process or means, to enhance the engineering soil as a material to give the required properties. Soils are stabilized to enlarge strength and durability or to prevent erosion, generation of dust, and reduce volume changes. In spite of the reason to carry soil stabilization, the required result is the development of a soil material that will remain stable under the design use condition for the expected project design life [Highway Design manual (1990)].

Civil or geotechnical engineers are main persons who are responsible for specifying or selecting the correct soil improvement method or technique, and amount of added improvement materials. The major part for the success in soil improvement or stabilization is soil testing procedure. The selected method or technique for soil improvement must be checked or verified through laboratory soil testing before the start of construction and preferably before choosing suitable materials, [Highway Design manual (1990)].

Generally the precautions taken in this field may be divided into:

a) By-pass the site.
b) Soil replacement.

The high cost of soil replacement has lead or driven engineers to search for other methods, and the process of soil stabilization is one of these alternative methods.

In past years, different advanced scientific techniques have been used to improve or stabilize soil. The soil improvements techniques are sometimes use the additives such as cement, lime or industrial products for soil stabilization. Previous research studies investigated the improvement or stabilization of soils using additives [Basha, *et al*., (2005)]. Improvement of pavement subgrade has previously depend on soil treatment with, special additives such as pozzolanic materials and lime and cement. Pozzolanic waste materials such as Fly Ash, Silica Fume and Rice Husk Ash, were used previously in the research of Yoder and Witczak, (1975) for soil improvement. And many other substances may be used for stabilization such as emulsified asphalt and tire chip and others.

Sand or clay sometimes is added to treat the lack of grading of a soil. Sand may be added as improvement to clayey soils and clay to sandy soils. The engineering properties such as the sandy soil strength and cohesion are increased through adding clay. While moisture transition or movement in clayey soil is minimized when sand is added. The improvement of soil material grading will not strength or stabilize the soil well, but will reduce the effect of other stabilizers. The clayey soil must be smashed or pulverized before mixing with the sandy soil, [Highway design manual 1990)]. The cohesionless or sandy soil can gain some cohesion strength through the rearrangement or redistribution of grains or particles in soil and minimize or decrease the voids between them through using fine particles between them. Also, this will decrease voids and increase the soil unit weight or density and therefore the required properties can be developed.

The main objectives of this paper are the improvement of some properties of sandy soil by using bentonite. The selected study properties are shear strength and maximum dry density which are effect the bearing capacity of structure foundations and their stability.

2. EXPERIMENTAL PROGRAM

2.1 Materials

The soil used in this research is brought from Al-Tajji, district in Baghdad the soil was classified by means of laboratory tests. The classification of soil helps the geotechnical engineer to specify or assign a soil to one of limited number of groups. The sorting is based on the engineering material properties and soil characteristics. Therefore, the laboratory cohesionless soil was distinguished or classified as SP (poorly graded fine sand) according to the Unified Soil Classification System (USCS) [Smith (2006)]. The specific gravity value of the soil was obtained to be 2.70. The grain size distribution curve of the used soil is shown in Figure-1.

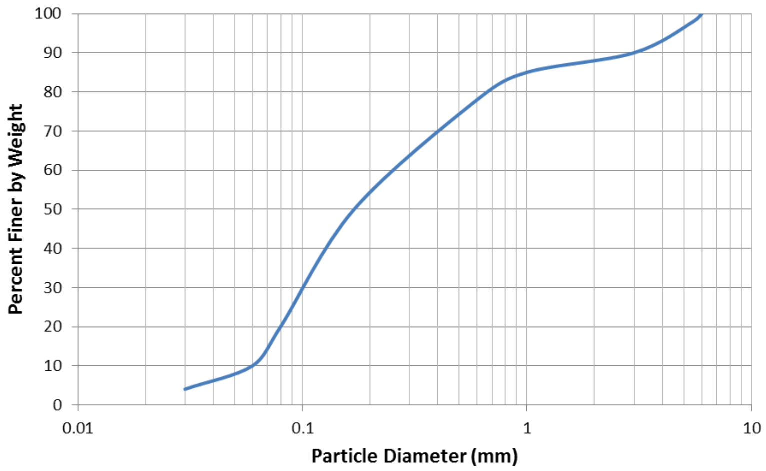

Figure-1. Particle Size distribution curves for the soil.

Bentonite is defined as clay formed by the alteration or chop of volcanic ash. The Bentonite, consisting majorly or predominantly of smectite minerals, usually montmorillonite. The Bentonite clay carries or have a very strong negative charge which stocks to the positive charge in many toxins. Their volume enlarges in size when being in contact with water which creates a gelatinous and viscous fluid [Budhu (2011)]. The engineering properties of Bentonite (swelling, water absorption, viscosity, hydration,), leads to make Bentonite a very important engineering material for a wide applications and uses. Therefore it is used mainly as a greasing or lubricant agent in foundations and diaphragm walls, in tunneling installation, in horizontal drilling and pipe jacking [Huchinson*et al.* (1975)].

2.2 Methods

Before using in the mixture, the cohesionless soil was first oven dried at 105°C. Five bentonite contents of 3, 6, 9, 12, and 15% by weight were used. For the cohesionless soil-bentonite mixtures, the method or procedure given in the BS 1377: Part 4:1990: 3.3 using the "Ordinary" compaction laboratory test (2.5 kg rammer method) was used to calculate the soil maximum dry unit weight or density and the optimum moisture or water content. The soil mixtures including Bentonite, were fully or thoroughly mixed. Firstly, compaction tests were made to investigate and determine the untreated soils compaction properties. Secondly, laboratory tests to find the treated soils proctor compaction properties with varying amount of Bentonite were carried out [Lamb and Whitman (1969)].

One of the major soil material properties is the shear strength. This property means the ability of soil to resist sliding along internal surfaces within a mass. The stabilization or stability of excavation, the earth dam slope, the building foundation, the natural slopes of hillsides and ant other structure constructed on soil relies on the soil shearing strength along the expected slippage surfaces. There is a problem in the engineering field which does not contain involve the shear characteristic of the soil in some manner or the other [Murthy (2013)].

The direct shear test is known as one of the ancient soil testing that used in calculating the shear strength. Shear laboratory tests were carried out on the cohesionless or sandy soil-Bentonite mixtures as per

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ASTM Method [ASTM D 3080-2004]. The used shear box was consisted of two halves of size 6×6×2 cm. The mixed materials were transferred to the shear box carefully in three layers with compaction to achieve the corresponding maximum unit weight. And, five normal stresses of 25, 50, 75, 100, and 125 kN/m2 were used to consider the stress range in field applications. Keeping the shear rate at 0.5 mm/min for all tests in order to simulate a rapid, quasi-undrained condition. The tests were continued until the shear stress became constant.

The effect of Bentonite on the cohesionless soil, as observed from the above test methods, is presented in the followings.

3. RESULTS

3.1Effect of compaction

Figure-2 shows the dry density moisture content relationships or curves of soil-Bentonite mixture. From these relationships, the values of maximum mixture dry density and optimum moisture or water content can be obtained. The compaction curves shapes for the treated soil is similar to that of the untreated. The maximum dry unit weight or density of the soil-Bentonite mixtures increases with increasing Bentonite content as the Bentonite have higher specific gravity. It is obvious from the same figure that there is no considerable effect of Bentonite content on the optimum moisture content value. Kalkan and Akbulut (2004) stated in their research that the high density of Bentonite, which filled the composite samples voids in order to enlarge maximum dry density.

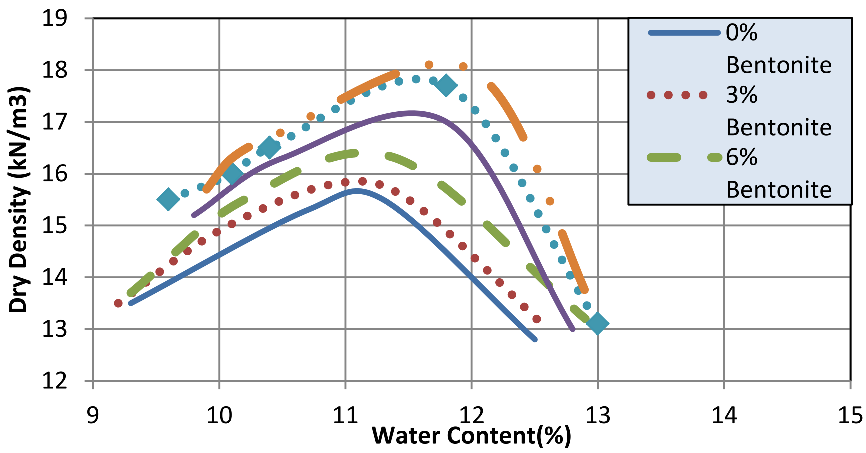

Figure-2. Effect of Bentonite percentage on moisture content and dry density curves.

3.2Effect on direct shear behavior of cohesionless soil

Direct shear laboratory tests were carried out or performed on cohesionless soil-bentonite mixtures under normal or direct stress ranging from 25 to 125 kPa. The peak or maximum value of shear stress failure is very obvious or clear. Figure-3 shows the typical curves of shear stress-horizontal deformation or displacement which are obtained at a normal or direct stress of 50 kPa. From the figure, it can be observed that at low shear deformation or displacement, the initial treated cohesionless soil modulus is lesser than that of the untreated soil but the treated soil shows larger shearing resistance than the cohesionless soil at higher values of shear displacement. The behavior is recognized to have similar trends at other normal or direct stresses.

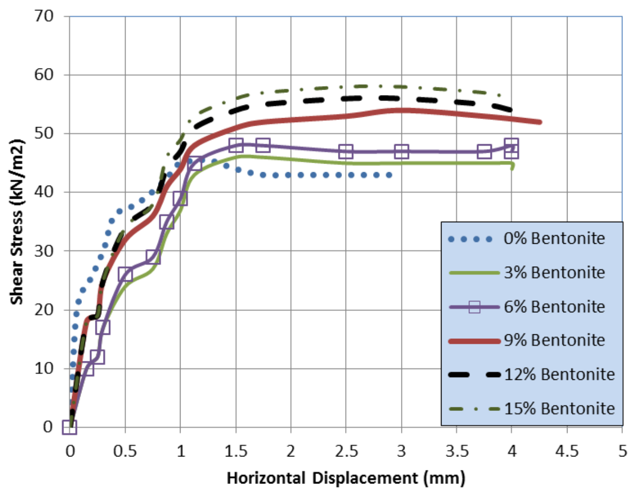

Figure-3. Shear stress verses horizontal displacement of soil Bentonite mixture.

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From Figure-4, it is obvious that the untreated soil sample has a low cohesion value due to the small 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 which represents the cohesion (C) value. Values of angle of internal friction (Ø) can be founded from the slope of the same line.

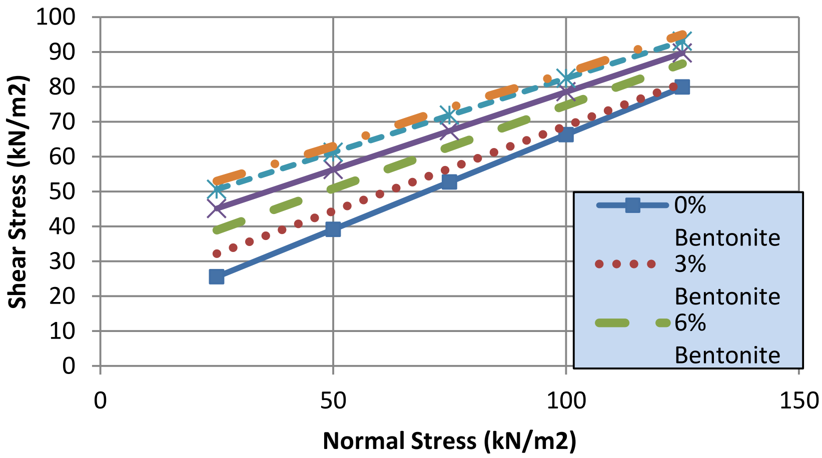

Figure-4. Failure envelope of soil Bentonite mixture.

From the results shown in Figure-.5, it can be concluded that:
The increasing in the percentages of Bentonite of soil samples leads to increase the cohesion. The increase in cohesion is very clear 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.

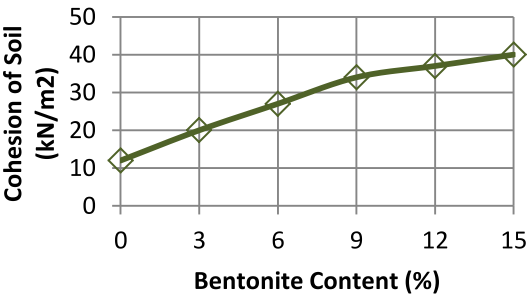

Figure-5. Variation soil cohesion with Bentonite content.

In Figure-6, the variation of Bentonite content with angle of internal friction of soil is shown. The difference or variation in angle of internal friction (Ø) is found be small after Bentonite content of 9 %. From these figures, it is obvious that the optimum value or percent of Bentonite which may be added to cohesionless soil is 9%.

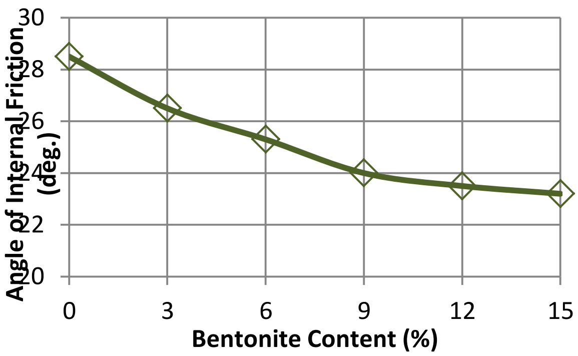

Figure-6. Variation soil angle of internal friction with Bentonite content.

4. CONCLUSIONS

The conclusions drawn from this research study are:

a) The maximum dry unit weight or density of the soil is increased with the addition of Bentonite and this is due to the capability of Bentonite to fill the soil voids. The plasticity of the cohesionless or sandy soil can be improved by using the Bentonite. As the Bentonite increased in content from 3% to 9%, the maximum dry density increased by about 12% while it is increased by about 5% if the Bentonite content increased from 9% to 15%.

b) The cohesion of the soil can be improved through using Bentonite. The increasing of Bentonite percentage from 3% to 9%, the cohesion (C) of soil increases by about 70% while for Bentonite content varies from 9% to 15% the soil cohesion increased by 19%.

c) The value of angle of internal friction decreased by 9% with increasing of Bentonite from 3% to

9% and by 3% for increasing Bentonite from 9% to 15%. Therefore the effect of Bentonite will be lesser on soil angle of friction for Bentonite content greater than 9%.

d) The optimum value of Bentonite added to the cohesionless soil is found to be 9% which give the improved results over other Bentonite content.

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