Experimental Study to Effect of adding Emulsion Rubber Material (SPR) for the shear parameters of soil Gypsum

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Abstract

The gypsum is considering one of the problematic soils due to the dissolution of gypsum that occurs when water table or rainfall fluctuates and/or infiltrates into gypseous soils. This paper studies the effect of the emulsified rubber (SPR) material on (shear parameters C & υ) the cohesion and the internal friction angle of the gypseous soil. The direct shear test was performed on gypseous soil with different SPR percentages (2, 4, 6 and 8%). The natural gypseous soil was 18.95. The shear strength parameters of the treated soil by SPR are higher than the natural gypseous soil due to the increasing in the cohesion due to increase the shear strength of gypseous soil. The best percentage of SPR to treatment and improve the mechanics of gypseous soil is 2% SPR to be 23.5.

1. Introduction

Gypsum is defined as a mineral salt exhibited equally chemical compound (Hydrated Calcium Sulphate) and the chemical symbol is being (CasO₄.2H₂O). It is shaped by percentage of (20.9%) combined with element of water (H₂O) Sulphur Trioxide that the chemical symbol is been (SO₃). Also It is shaped by percentage of 32.5% Calcium Oxide and the chemical symbol is being (CaO). The specific gravity of Gypsum has low equally to (2.32) therefore this brought about large effect on the properties of physical and mechanical of the soil comprising a large amount of these minerals. Gypsum is typically a sedimentary mineral that is widespread and is followed with sandstone, shells and carbonate rocks [1].

Shear Strength test and the Effect of Leaching

The shear strength of the soil is the internal force per unit area that soil mass can offer to resist failure [2].

\[ \tau = c + \sigma \tan \varphi \]  \hspace{1cm} (1)

Where
- \( \tau \) = the shear strength of soil equal to shear force to area = S/A
- \( c \) = the cohesion of soil mass
- \( \varphi \) = the angle of shearing resistance for soil
- \( \sigma \) = the normal stress equal to normal force to area soil mass =N/A
This may basically refers to noteworthy reductions in the shear strength associated with gypsum wetting and dissolution [3];[4]; [5];[6],[7];[8] investigated the effect of leaching on the behavior of gypseous soil [9].

2. Objective:
The objective of this research is to study the effect the parameters of shear (C cohesion & $\varphi$ internal friction) of the gypsum soil before and after treatment by addition an SPR (Styrene Butadiene Rubber).

3. Materials and Experimental Tests
The materials used in this study selected from the local materials used in road construction in Iraq.

3.1 Materials
The materials used in this study describe as shown below:

3.1.1. Soil
The soil sample used is obtained from Tikrit with gypsum content (53 %). A summary of the classification tests of the soil used is shown in Table (1). The soil used can be classified as (SW-SM) according to (USCS).

| Table 1. the value of Index Property soil |
|-----------------------------------------|
| Index Property s                        | Index Value | Standards                  |
| Gypsum content (%)                      | 53          | ASTM D422-2001 [10]        |
| Sand %                                  | 92          | ASTM D422-2001             |
| Silt & clay %                           | 8           | ASTM D422-2001             |
| Coefficient of uniformity Cu            | 7           | ASTM D422-2001             |
| Coefficient of curvature Cc             | 2.7         | ASTM D422-2001             |
| Soil classification (USCS)              | SW-SM       | ASTM D422-2001             |
| Specific gravity (Gs)                   | 2.39        | ASTM D854-2005 [11]        |
| Optimum moisture content (%)            | 11.2        | ASTM D-698     [12]        |
| Maximum dry weight (KN/m3)              | 16.8        | ASTM D4253-2000 [13]       |
| Minimum dry weight (KN/m3)              | 11.5        | ASTM D4254-2000 [14]       |
| D$_{10}$                                | 0.1         | -                         |
| D$_{30}$                                | 0.19        | -                         |
| D$_{60}$                                | 0.7         | -                         |
| Liquid limit (L.L) %                    | 24.5        | -                         |
| Plastic limit (P.L) %                   | 5.18        | -                         |
| $\varphi$ internal friction             | 34.5        | ASTM D3080-2014 [15]       |
| dry density (KN/m3)                     | 15.2        |                           |
| E                                       | 0.57        |                           |
| R.D.                                    | 77 %        |                           |

3.1.2 Additives
The additives used in this study include

**SPR**: is termed to **Styrene Butadiene Rubber** copolymer based product that is utilized in concrete as an admixture and bonding factor to increase its water resistance and durability. It is one of the chemical additives proposed to be used in order to improve the properties of the soil stabilized with SPR. This material is obtained from the local market.
Table 2. Chemical Composition of the SPR

| Properties                        | Value                      |
|----------------------------------|----------------------------|
| Color & appearance               | White milky liquid         |
| Ph                               | 9-10.5                     |
| Density (g/cc)                   | 1.01( + or - ) 0.05        |
| Soil content ,(%)                | 45 ( + or - ) 3            |
| Compressive strength (N/mm²)     | >40                        |
| Flexural strength (N/mm²)        | >12                        |
| Tensile strength (N/mm²)         | >6                         |
| Water vapour transmission (g/m²/24 hrs) | <4                     |
| Shear Board Strength (N/mm²)     | >5                         |
| Application temp, (C°)           | 5 to 45                    |
| Service temp, (C°)               | -5 to 45                   |

4. Data Analysis and Testing Results

4.1. Shear Strength Test
To study the shear strength parameter for soil gypsum, shear strength test was carried out for such soil in its natural state and after treatment. Figure 1 refers to relationships between shear stress and normal stress at natural soil state. Figures 2-5 refer to relationships between shear stress and normal stress such as soil after treatment by addition SPR material. From the aforementioned figures, one can note that the value of internal friction and soil cohesion is variable with the addition of SPR%. The cohesion (C) for soil increases with increasing SPR ratio from (18.95) at natural soils (without adding SPR%) to be (23.5, 22.5, 20, and, 16) at addition SPR (2%, 4%, 6% and 8%) respectively. The internal friction (φ ) for soil decrease with increasing SPR ratio from 22° at natural soils (without adding SPR%) to be (15, 19) at addition SPR (2%, 4%) respectively, while increase to be 22.57 and 23.52 at SPR ratio 6% & 8% respectively. Therefore, the best percentage of SPR was 2% as a summary for the value of the Table 3 is drown.

Table 3. Maximum Shear Stress at different Percentage of SPR

| The Value of Percentage of SPR | Maximum Shear Stress | Normal stress | Internal friction | Cohesion |
|-------------------------------|----------------------|---------------|-------------------|----------|
|                               | I kg                | 2kg           | 4kg               | σ1       | σ2       | σ3       | φ        | C        |
| (0%)                          | 18.9525             | 38.9519       | 74.366            | 27.8     | 55.56    | 111.11   | 22.00    | 13       |
| (2%)                          | 28.519              | 32.49         | 81.0445           | 27.8     | 55.56    | 111.11   | 15.59    | 23.5     |
| (4%)                          | 26.5335             | 46.208        | 81.947            | 27.8     | 55.56    | 111.11   | 19.82    | 22.5     |
| (6%)                          | 25.631              | 52.706        | 74.005            | 27.8     | 55.56    | 111.11   | 22.57    | 20       |
| (8%)                          | 20.938              | 55.233        | 75.449            | 27.8     | 55.56    | 111.11   | 23.52    | 16       |
**Figure 1.** Relation between shear stress and normal stress Without add SPR

**Figure 2.** Relation between shear stress and normal stress at 2% SPR for normal stress

**Figure 3.** Relation between shear stress and normal stress at 4% SPR for normal stress

**Figure 4.** Relation between shear stress and normal stress at 6% SPR for normal stress
5. Conclusions
1. Soil cohesion particles soil is increased with addition SPR material that leads to increase the shear strength for soil.
2. The best-added ratio (SPR) is 2% which is measured by the strength of the internal adhesion granules of soil, as well as the constipation of the granules with their ability to the cohesion of particle soil, is good.

References
[1] Nashat I H 1990 Ph.D. Thesis Department of Civil Engineering, University of Baghdad.
[2] FAO 1990 Soils, Food and Agricultural Organization of the United Nation, Rome.
[3] Horta J G 1980 Engineering Geology 15(1) 15-52.
[4] Al-Muhammadi N 1987 Proceeding of the 6th Asia Conference of Soil Mechanics, Tokyo.
[5] Terzaghi, K 1936 Proceedings of 1st International Conference of Soil Mech. Found. Eng. Cambridge I 54-56.
[6] Kazi A and Moun J 1973 Proceeding of International Symposium on Soil Structure, Gothenburg, Sweden I 135-152.
[7] Torrance J K 1974 Geotechnique 24 (2) 155-173.
[8] Mikheev V V, Petrukhin V P and Boldirev G V 1977 Proceeding of 9th International Conference on Soil Mechanics and Foundation Engineering I 211-214.
[9] Petrukhin V P and Arakelyan E A 1985 Soil Mechanics and Foundation Engineering 21 (6) 23-25.
[10] Al-Khuzaie H M A 1985 M.Sc. Thesis, Civil Engineering Department, University of Mosul.
[11] Seleam SN 1988 M.Sc. Thesis Building and Construction Department, University of Technology.
[12] Taha S A W 1979 M.Sc. Thesis college of Engineering. University of Mosul.
[13] ASTM D422-2001. American Society for Testing and Materials
[14] ASTM D854-2005. American Society for Testing and Materials

Figure 5. Relation between shear stress and normal stress at 8% SPR for normal stress
[15] ASTM D-698, American Society for Testing and Materials
[16] ASTM D4253-2000, American Society for Testing and Materials
[17] ASTM D4254-2000, American Society for Testing and Materials
[18] ASTM D3080-1998, American Society for Testing and Materials