Tire Rubber Waste for Improving Gypseous Soil

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Abstract. Each year large quantities of tire wastes are released to the environment in an undesirable way. Those waste materials cause many environmental and economic problems. This study introduces an attempt to improve Gypseous soil properties using rubber tires waste.

This paper presents an experimental study that explores the possibility of using rubber tires waste as an additive to improve the strength of gypseous soils. Different percentages of the waste material (2, 4, 6 and 8%) were mixed with the designated soil. The obtained results show that the angle of internal friction increases significantly with the addition of a different percentage of tire residues, unlike cohesion which was barely affected. In addition, the waste tires rubber minimizes the maximum dry density and optimum moisture content for this type of soil. The difference in optimum moisture content and maximum dry weight with the addition of waste fraction is linear.

1. Introduction

Scrap tires are increasing every year which is causing a major environmental problem [1]. Rubber tires particles are using in landfill engineering as subgrade reinforcement for construction roads over soft soil or for improvement some physical and engineering properties of collapsible soil. Cetin et al. (2006) suggested using waste tires rubber application in civil engineering due to the [2]:

1. Low density.
2. High durability.
3. High thermal insulation.
4. Low cost compared with the other fill materials.

Gypseous soil is a rich soil with salt deposited which is one of the many types of collapsible soils. The problems are associated with water seepage through the soil; the gypsum dissolves thus causing subsidence of the ground level. In order to understand this problem, it should be prevented or reduce the dissolution of gypsum in the soil [3]. Many researchers was studied during the last 3 decades the treatment of that problem, some of them were physical treatment like cement addition, earth reinforcements and stone piles while the other were chemical treatment like treatment by Lime, Clinker, Polycoat, Emulsified Asphalt or fuel oil [4,5,6,7]. Other researchers studied the effect of adding waste tires as an improvement material, [8] study the effect of replacing sand aggregate grain size with wastes rubber and plastics at different mixing ratio. Also [9] made a numerical analysis for a reinforced wall using rubber tire chips-
sand mixtures as backfill material. [10] Presents a laboratory study showed the effect of granular rubber waste tire on the physical properties of a clayey soil.

This paper presents an experimental study for improvement properties of Gypseous soil by mixing it with rubber tire particles which is one of the most little cost material.

2. Materials

2.1 Waste tires rubber

The material used in this study was the waste of rubber tires for bicycles Figure (1) and was manually cut by scissors with squares (1cm²) and thickness (3 mm).

![Figure 1. Tires Rubber Waste.](image)

2.2 Soil

This study performed on natural Gypseous soil which it had highly gypsum content (41.24%). The soil was taken from Tikrit city in Salah-Aldeen governorate (Tikrit University). Samples were taken from depth range (1.0-3.0) meters below the ground surface after excavating the upper soils strata.

3. Results and Discussions

3.1 Properties Tests

The physical tests are computed for samples taken from depth 2 meters below the ground surface. The obtained samples (disturbed and undisturbed) were taken to the soil mechanic laboratory, Civil Engineering Department, College of Engineering at the University of Tikrit. The grain size distribution result as shown in Figure (2), the soil is poorly graded sand (SP) according to the United soil classification (USC). The properties of soil are shown in Table (1). All the above tests conducted according to the ASTM specification [11] except the specific gravity which was conducted according to the British Standard [12].
Figure 2. Grain size distribution curves for the soils used in the study.

Table 1. Properties of the Gypseous soil.

| Soil Properties          | Value       |
|--------------------------|-------------|
| Water Content (OMC) (%)  | 4.9         |
| Specific Gravity         | 2.75        |
| Liquid Limit (%)         | 26          |
| Plastic Limit (%)        | N.P         |
| Plasticity Index (%)     | ----        |
| Maximum Dry Density (MDD) (gm/cm$^3$) | 1.44 |
| Gypsum Content (%)       | 41.24       |

3.2 Direct Shear Test

The direct shear test was conducted according to the ASTM (D3080-72), which was used to determine the shear strength parameters, the cohesion ($c$) and the angle of internal friction ($\phi$). Direct shear test conducted first on the undisturbed sample, and the value of the cohesion ($c$) and angle of internal friction ($\phi$) was (3.1N/mm$^2$) (28.9°) respectively. Direct shear test conducted on a disturbed sample which re-molded with adding a different percentage of waste tire rubber content (0, 2, 4, 6, 8%) as shown in Table (2). It could be observed that the angle of internal friction ($\phi$) of gypseous soil increased significantly by adding a different percentage of waste tire rubber. The reason of this behavior may be related to increasing in the surface of friction between soil particle and the rubber particle, which is the surface area of the rubber particle greater than that for the soil particle.
Table 2 Results of Direct Shear Test for Gypseous Soil.

| Rubber waste content (%) | Cohesion (N/mm²) | Friction angle (φ °) |
|--------------------------|-----------------|---------------------|
| 0                        | 3.1             | 28.9                |
| 2                        | 3.4             | 34.6                |
| 4                        | 3.6             | 37.5                |
| 6                        | 4.1             | 41.2                |
| 8                        | 4.8             | 47.8                |

3.3 Compaction Test

Standard Procter Compaction test was used to obtain maximum dry unit weight (MDD) and optimum moisture content (OMC) of untreated and treated soil samples according to the procedure of ASTM designated as D1557-79 [13].

As shown in Table (3) which related moisture content and dry unit weight of gypseous soil with adding a different percentage of waste tire rubber content (0, 2, 4, 6 and 8%). It could be observed that rubber particle decreased the maximum dry density for the soil because that the specific gravity of the rubber is less than that for the soil. It could benefit from this point by using the rubber particle in the construction of embankments or as reinforcement material in geotechnical works [10]. Also, it could be observed that adding rubber particle decreased the optimum moisture content because rubber particle does not suck water.

The difference in optimum moisture content and maximum dry density with the percentage of waste tire rubber ratios is linear as shown in Figure (3), and Figure(4) and the shape of the curving curves is similar to that of the rubber-free samples added.

Table 3. Results of Compaction Test.

| Rubber Content (%) | OMC (%) | MDD (gm/cm³) |
|--------------------|---------|--------------|
| 0                  | 18.65   | 1.44         |
| 2                  | 18.33   | 1.40         |
| 4                  | 18.11   | 1.37         |
| 6                  | 17.92   | 1.34         |
| 8                  | 17.73   | 1.32         |
4. Conclusion

Based on the testing results of effect tired rubber for improvement Gypseous soil the following conclusions can be drawn

1. Addition waste tires rubber to Gypseous soil increases the value of cohesion but not significantly.

2. The angle of internal friction for the Gypseous soil increases significantly with the addition of different proportions of tire residues.

3. The waste tires rubber cut minimizes the maximum dry density of the soil and optimum moisture content. The difference in optimum moisture content and maximum dry weight with the addition of waste fraction is linear.
4. The shape of the curves of the soil containing the rubber pieces is similar to the models without additives

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