# Geotechnical Improvement of clay Soil by using waste Tire rubber

**Civil Eng. :** Aram Hama Tofiq Abdalqadir

**Card No. :** ٦٩٠٧

# Content

# Abstract:

In Sulaimani-Iraq the uses of Automobiles are increasing day by day because of that the waste of tyres increases the waste tyres are classified as solid waste. Due to manufacturing of tyres with synthetic rubber, proper disposal of these waste tyres has become difficult. Rubber tires pose a major fire hazards and therefore, there is an Increasing demand for the safe disposal or use of waste rubber tires. As a result of this, there is a great damage to eco-system like air pollution and aesthetic pollution. Waste materials are widely spread throughout the world, which have become one of the major problems in the world. The geotechnical community has been trying to incorporate shredded rubber tires in various applications such as in the pavements of roadways and highways, the backfill of retaining walls, etc. Thus In this study, the effort of inclusion of waste rubber tyres on the clayey soil has been investigated. Waste tyres were added to the soil in the proportion of ٤%, ٨%, ١٢٪ and ١٦% by weight, shredded rubber tires with different sizes (١٠mm to ٢٠mm) in diameter and (٢٠mm to٣٠mm) in length were obtained and Unconfined Compressive Strength Tests and California bearing ratio tests are conducted for cohesive soil. Moreover, California bearing ratio (CBR) and unconfined compressive strength increased with the addition of waste tyres and Maximum dry density (M.D.D) were decreased with the addition of waste tyres.

**Keywords:** Soil stabilization, Waste rubber tyres, CBR, Unconfined compressive strength M.D.D.

# ١. INTRODUCTION

There is an increasing demand to find alternative uses or determine safe disposal methods for used rubber tires due to the major fire hazard they pose. Various applications for the use of these waste tires have been proposed by the geotechnical engineering community. Two suggestions among them are – a) Use as a backfill material for the retaining structures, and b) Use as a fill material for the sidewalks and other walkways. To use the shredded waste rubber tire for these applications, it is important to determine the proportion of rubber tire in different types of soil that gives maximum dry unit weight with less moisture.

Soil stabilization is a technique to improve the soil parameters such as shear strength, compressibility, density, hydraulic conductivity etc. The techniques of soil stabilization can be categorized into a number of ways such as consolidation, vertical drains, vibration, surcharge load, admixtures, grouting and reinforcement and other methods. Geotechnical engineers around the world are in search of new alternate materials which are required both for cost effective solutions for ground improvement and for conservation of scarce natural resources. the number of vehicles on road is increasing day by day. This increase in growth apart from causing noise and air pollution has begun to cause pollution in terms of stock piles of discarded tyres. Many countries already banned the disposal of the waste tires in sanitary landfills.

Apart from the environmental benefits of recycling waste tires also has tremendous potential of generating wealth. To address the above concerns rubber tyre is an additive to improve the industry. The use of discarded waste tires as an engineering material is gaining popularity among civil engineering fraternity due to its low density, high strength, resilience and high frictional strength, which are essential from the geotechnical engineering perspective.

# ٢. LITERATURE REVIEW

**Zornberg et al (٢٠٠٠)** conducted a field investigation to assess the mechanical behaviour of an experimental embankment fill built with tyre shreds and cohesive soil. Immediately after construction, the embankment was submitted to heavy truck traffic and settlements were monitored for over two years. The results indicate that the embankment sections built with tyre shreds and cohesive soil showed satisfactory long term performances during traffic exposure.

**Hassana et al (٢٠٠٥)** based on their tests involving triaxial test and CBR test on shred tyre reinforced soil, concluded that the presence of shredded waste tyres in sand improves the stress-strain properties for all different sizes and contents of shreds waste tyre over that pure sand. The maximum deviator stress of randomly reinforced sand occurs at a higher axial strain compared to sand alone. CBR values increases with the increase of shreds tyre content up to ٣ % content. After this content the increasing of CBR value decreases with the increase of shreds tyre content in both soaked and unsoaked specimens.

**Prasad et al. (٢٠٠٨)** carried out CBR and direct shear tests for finding the optimum percentages of waste plastics and waste tyre rubber in gravel subbase material. Based on these results, laboratory model pavement studies were conducted with optimum percentage of waste plastics and waste tyre rubber in gravel subbase, laid on expansive soil subgrade in the flexible pavement system. The load carrying capacity of the model flexible pavement system significantly increased when the gravel subbase was reinforced with waste plastics as well as waste tyre rubber when compared to unreinforced subbase.

# ٣. Materials and Methods

**٣.١ Soil:** Various field trips were conducted to visit specific locations before starting this study. The location was selected to cover a wide range of cohesive soils. Table ١ illustrates the location of the selected site for soil sampling in Sulaimani City.

**Table ٣.١:** Location of the selected site for soil sampling and their and Atterberg limits.

| **Location** | **Latitude** | **Longitude** | **Liquid limit (%)** | **Plastic limit (%)** | **Plasticity index** |
|---|---|---|---|---|---|
| Bakrajo (B) | ٣٥° ٣٣' ٣٧"N | ٤٥° ٢٠' ٤٤"E | ٥١.٥٥ | ٣٠.٨٩ | ٢٠.٦٦ |

**٣.٢ Sample Collection**

١- **Cohesive soil:** all soil samples were taken from a depth of ٠.٥ to ١ meter from the natural ground surface. The collected samples were kept undisturbed by extracting them via thin wall and directly put in plastic bags in order to save their field moisture content. Then, the samples transported to the soil laboratory.

**Table ٣.٢:** Some of the geotechnical properties of the cohesive soil sample.

| Property | Standard | Soil B |
|---|---|---|
| Liquid Limit (%) | ASTM D ٤٣١٨-١٤ | ٥١.٥٥ |
| Plastic Limit (%) | ASTM D ٤٣١٨-١٤ | ٣٠.٨٩ |
| Plasticity Index (%) | ASTM D ٤٣١٨-١٤ | ٢٠.٦٦ |
| Specific Gravity | ASTM D ٨٥٤-١٤ | ٢.٦١ |
| Maximum dry density (kN/m$^٣$) | ASTMD ١٥٥٧-١٢ | ١٧.٥ |
| Optimum moisture content (%) | ASTMD ١٥٥٧-١٢ | ١٨.٤ |
| California Bearing Ratio (%) | ASTM D٨٨٣-١٦ | ٣.٦٥ |

**Waste tyre rubber:** The Waste Tyre Pieces used for this investigation is obtained from a Tyre Shop in Sulaimani City, The properties of the Waste Tyre pieces are given in Table ٣.٣.

**Table ٣.٣:** Some of the geotechnical properties of the cohesive soil sample.

| Property | Value |
|---|---|
| Colour | Black |
| Shape | Cylindrical |
| Specific Gravity | ١.٣٩ |
| Diameter | ١٠mm to ٢٠mm |
| Length | ٢٠mm to ٣٠mm |

## ٣.٣Methods

Soil samples were compacted in the consolidometer ring at the optimum moisture content and maximum dry density, which were obtained from the conducted modified proctor compaction test.

١- **Compaction test:** Modified proctor compaction test was used to find the compaction characteristics optimum moisture content and maximum dry density. Optimum moisture content and maximum dry density was found of soil mixed with shredded tyre of percentage ٤٪, ٨٪, ١٢٪ and١٦٪. And size (١٠mm to ٢٠mm) in diameter and (٢٠mm to ٣٠mm) in length and also optimum moisture content and maximum dry density was found by modified proctor compaction test

**٢- Preparation of Test Specimens for CBR and unconfined compressive strength Test**

For these tests, the soils samples were prepared at the M.D.D. and O.M.C. These properties were obtained from the conducted modified proctor compaction test and by adding the stabilization material percentages. After that, unconfined compressive strength was recorded.

# ٤. Soil Test Results and Discussions

## ٤.١ Compaction test

The plotted curves obtained from the carried out compaction tests for the natural soils and the mix for soils B, are shown in the Figures of ٤.١ This figure show the variation of O.M.C. and M.D.D. with the soil and waste tyre. The results show that the M.D.D. was decreased with an increase in the percentage of shredded rubber tyre. This is due to the light weight (relatively low specific gravity) nature of shredded rubber tyre. On the other hand the value of optimum moisture content is increased with increase in Percentage of shredded tyre. This is due to the fact that shredded tyre has some value of water absorption.

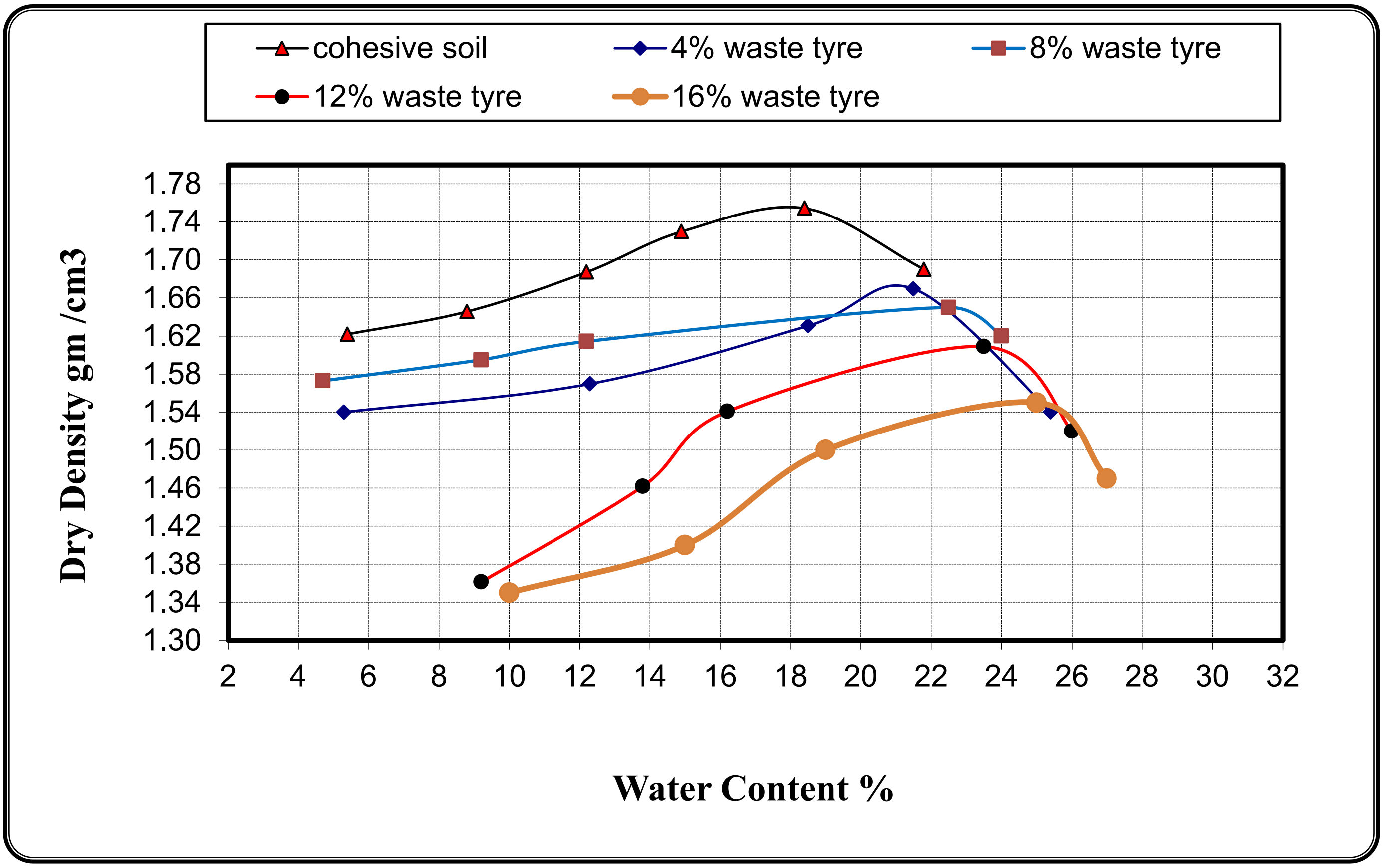


**Figure ٤.١** Variation of water content with the dry density.

## ٤.٢ Unconfined compressive test

The unconfined compressive strength test (UCS) was carried out for the soils B. To investigate UCS, the samples were compacted in the cylindrical mold at the optimum moisture content and maximum dry density which were obtained from the modified proctor compaction test.

The value of UCS was increased with the increase of waste tyre content up to ١٢%. This is because the waste rubber tyre efficiently reduced the further development of tension cracks. Therefore, the deformation of the soil was subjected to applied load and the total contact area between waste tyre and soil particles increased while increasing the waste tyre content. Consequently, the friction between them was increased, which contributes to the increase in the resistance to the applied forces. Figure ٤.٢ illustrates the increases of UCS with the increasing of waste tyre content.

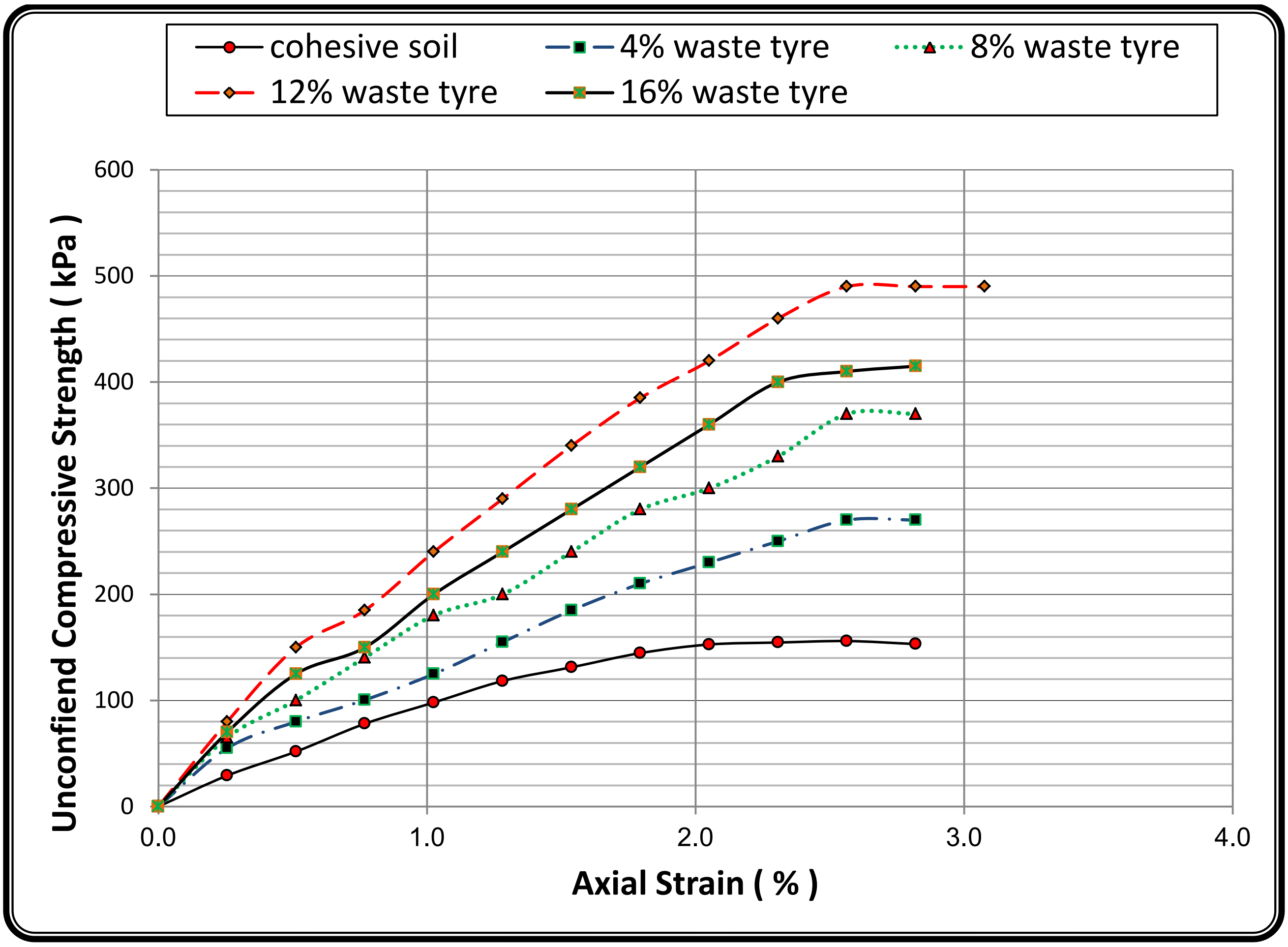


**Figure ٤.٢:** Variation of the UCS with waste tire and soil.

### ٤.٣ California bearing ratio CBR

The CBR test was carried out for the soil. In order to investigate the CBR value, the samples were prepared at the optimum moisture content, which was obtained from the modified proctor compaction test.

The effect of the mixture of the soil and the soil-waste tyre on the CBR value was obtained from Figure ٤.٣. This shows that the CBR was increased with the increased waste tyre up to ١٢٪. This increase of the CBR value due to the effect of WPB can efficiently impede the further development of tension cracks and deformation of the soil. Bond strength and friction at the interface seem to be the dominant mechanisms controlling the reinforcement benefit.

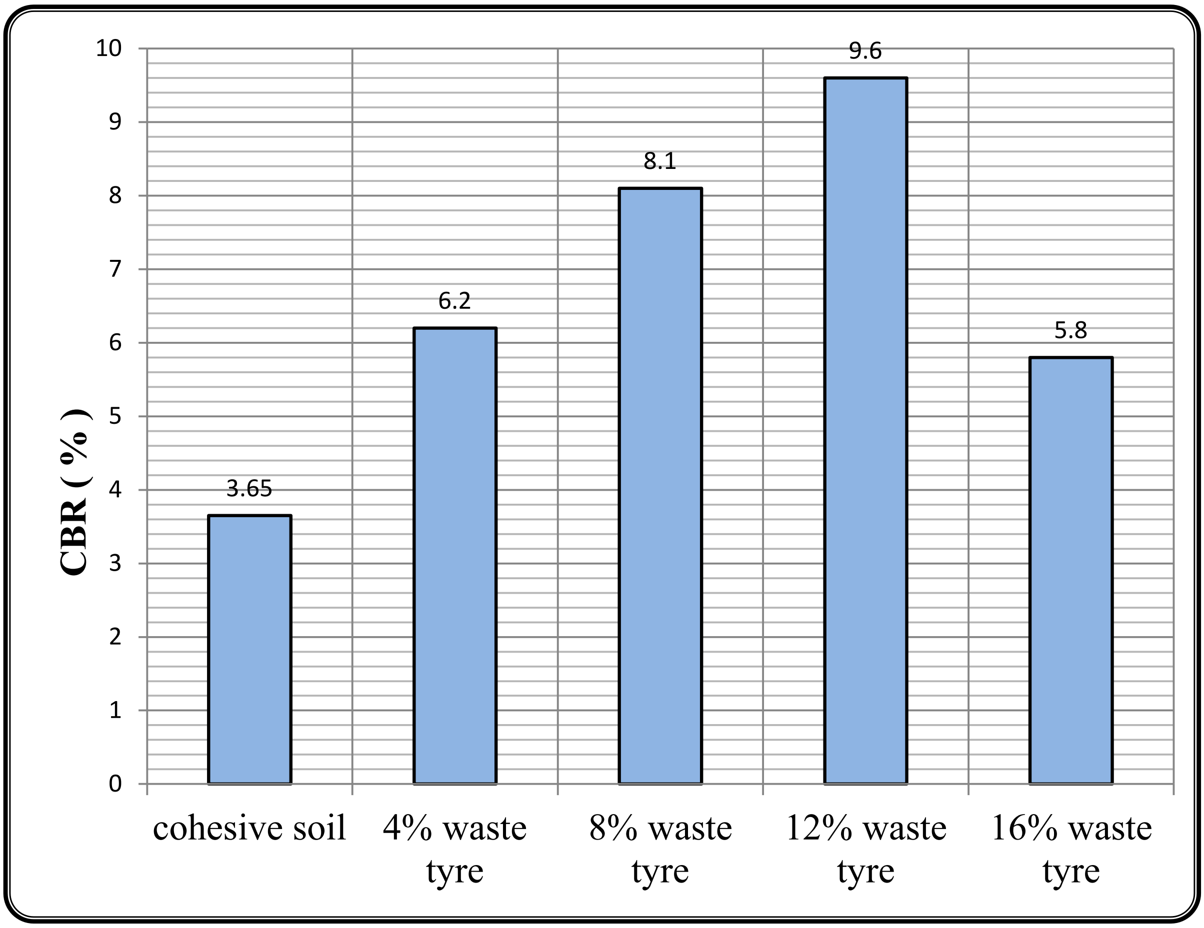


**Figure ٤.٣:** Variation of the CBR values for the untreated soil, and soil mixed with waste tyre.

# ٥. CONCLUSIONS

Based on the experiments carried out on soil and soil tyre mixtures, the following observations and conclusions are drawn:

١- The optimum moisture content is found to increase with increase in percentage of shredded tyre, because shredded tyres have some water absorption value. The maximum dry density of soil decrease with increase in percentage of soil. This is due to the light weight nature of tyre waste.

٢- The value of UCS was increased by addition of the waste tyre up to ١٢٪.

٣- The value of CBR was increased by addition of the waste tyre up to ١٢٪.

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