Effect of adding used tire aggregates on the mechanical behaviour of a clay

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Abstract. Several techniques in civil engineering, combining waste with soil, are known in the world. Waste tires are bulky, polluting and non-biodegradable waste. The association of these wastes with coherent soils can give efficient materials and solve several problems encountered by the engineer in the geotechnical sector. The objective of our study is to evaluate the effect of adding used tire aggregates on the mechanical behaviour of a clay. After the different materials are sieved, the prepared samples are then submitted to identification and mechanical tests, mainly: shear tests. In addition to the environmental benefit of the approach proposed in this study, the creation of a new application that allows to absorb a quantity of rubbery waste, the results obtained show that the addition of rubber aggregates to a clay soil, allows to improve the characteristics according to the different percentages of addition and the parameters of shear strength, by decreasing the cohesion and increasing the angle of internal friction.

1 . Introduction

To meet the needs of the construction industry, engineers and researchers have to pay particular attention to soil stabilization with the incorporation of stabilizers, in order to develop the production of construction materials in terms of both quantity and quality [1, 2].

There are several constructions, stabilization and reinforcement techniques that have been used in civil engineering to solve the problems encountered. The addition of used tire aggregates is one technique for improving the characteristics of poor-quality soils [3].

Tire waste is bulky, polluting and non-biodegradable. Combining them with cohesive soils can produce high-performance materials and solve a number of problems encountered by engineers in the geotechnical sector [4, 5].

2 Subject of the study

The main objective of our study is to investigate the effect of treating a clay with rubber from shredded used tires on its mechanical properties.

A laboratory application of the treatment on the soil studied with different rubber percentages of 2%, 4% and 6%.

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3 Experimental study

Before starting any work, it is essential to have an idea of the characteristics of the soil, in order to collect the necessary information that will help the geotechnical engineer in: selecting the type of soil (clay, silt, sand...) as well as the possible problems that may occur on the ground (settlement, swelling...) and establishing the necessary solutions.

3.1 Sample collection

The soil was extracted to a depth of around 2 to 3 m and sampled using a mechanical shovel. After extraction, the soil was placed in plastic bags and transported to the laboratory for preparation and performance of geotechnical identification and mechanical tests.

3.2 Identification tests

The results of the identification tests carried out on the soil used are presented in Table 1 below [6-8]:

Water content	23.22%
Limited liquidity	60%
The plasticity limit	19.13%
The density of solid grains	1.60
Dry density	1.03
Methylene blue value	7.4

The tire aggregates used are obtained by shredding of the used tires, where the rubber is separated from the textile fibers and metal threads also found in tires.

The used tire aggregates used in our study (Figure 1) have a diameter of less than 8mm [9].

Fig. 1. Rubber aggregates

The grading curve chosen for rubber aggregates is as follows (Figure 2):

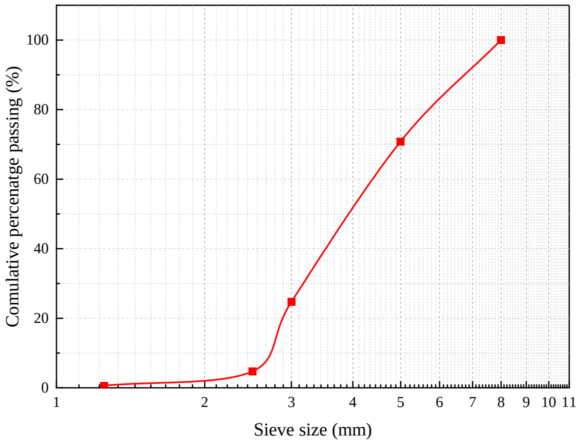

Fig. 2. Rubber grain size curve.

3.3 Mechanical tests

The various materials studied were subjected to mechanical laboratory tests, mainly Casagrande box shear tests in accordance with standard NF P94-071-2 [10].

The principle of the test is simple: a vertical force N is applied to the top of the test specimen, creating a normal stress in a horizontal plane. This force is measured as a function of time and the shear stress in the horizontal plane separating the two half-shells can be calculated.

3.4 Results and interpretations

The results of the shear tests are presented in the form of curves.

The following figures (3 to 6) show the variation in tangential stress as a function of horizontal displacement in the natural state and with different percentages of used tire aggregate added.

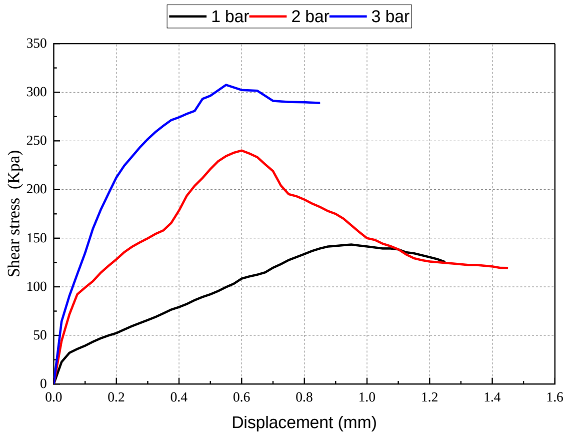

Fig. 3. Shear stress as a function of horizontal displacement (0% of rubber)

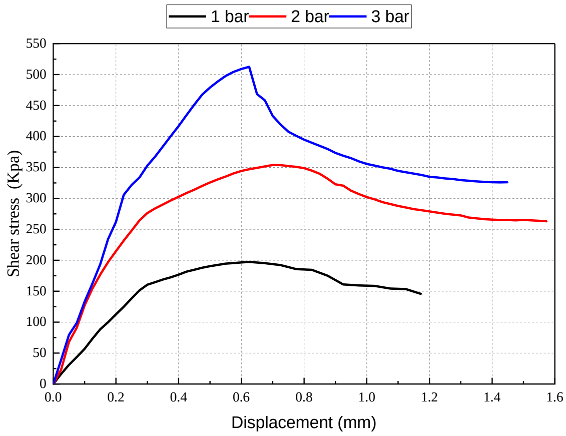

Fig. 4. Shear stress as a function of horizontal displacement (2% of rubber)

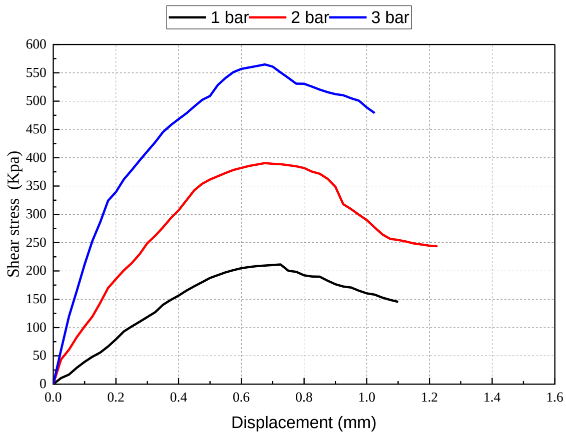

Fig. 5. Shear stress as a function of horizontal displacement (4% of rubber)

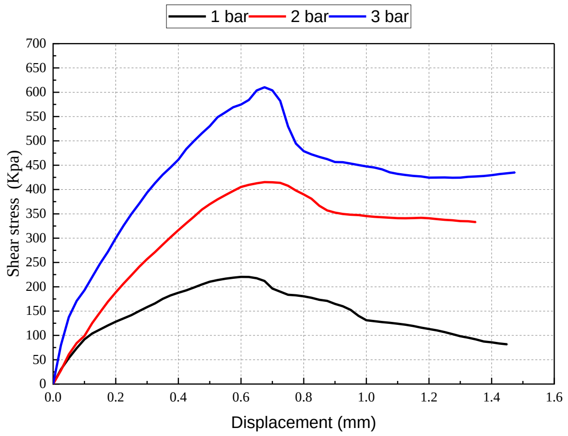

Fig.6. Shear stress as a function of horizontal displacement (6% of rubber)

The results show that shear strength increases with increasing normal stress. This is because the rubber aggregates tighten between themselves and with the clay particles, so friction will increase, resulting in higher shear strength after each test.

Shear strength is also related to the amount of rubber aggregate added to the soil. Indeed, under various normal stresses, the results obtained show a continuous improvement in shear strength as a function of the percentage of these aggregates added. This resistance is directly linked to the internal friction that occurs between the grains during shearing.

The figures 7 to 9, shows the variation of max shear stress as a function of percentage of rubber and normal stress.

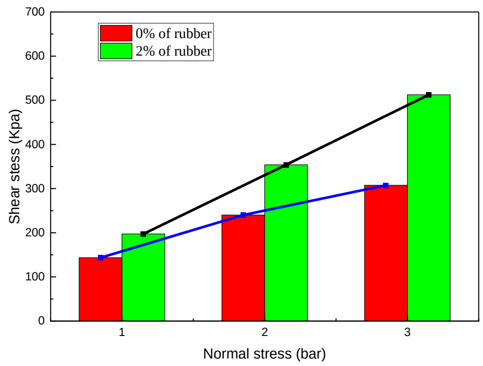

Fig.7. Variation of max shear stress as a function of percentage of rubber and normal stress (0-2% of rubber)

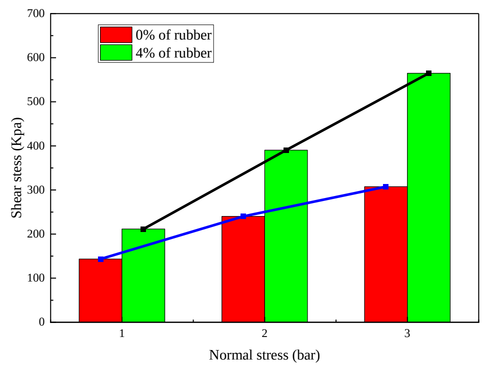

Fig.8. Variation of max shear stress as a function of percentage of rubber and normal stress (0-4% of rubber)

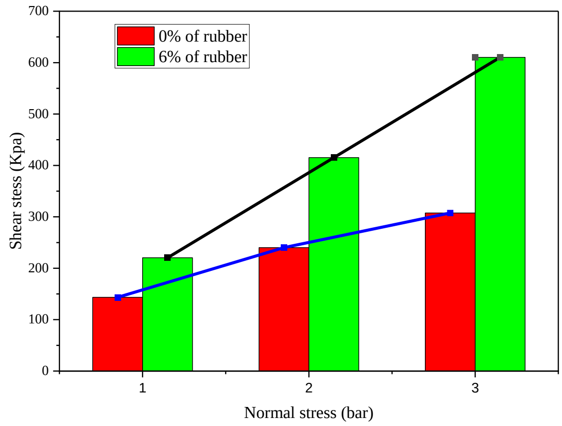

Fig.9. Variation of max shear stress as a function of percentage of rubber and normal stress (0-6% of rubber)

According to figures 7 to 9, the value of the maximum shear stress without addition increases from the value of 143.419KPa under a normal stress of 1bar, to reach the maximum value of 340.031KPa at 3bars. With the addition of 2% rubber, this value increases to 512.521KPa. With 4% rubber added, the maximum stress value is 554,980KPa. This value improves further to reach a maximum value of 610,235KPa at 6% rubber aggregate addition.

4 Conclusion

The aim of the work presented here is to study the effect of rubber granulates derived from the shredding of used tires on the mechanical properties of a clay soil. The aggregates were added to the clay in different dosages of 2, 4 and 6%.

Based on the results obtained, the main conclusions that can be drawn from this study are:

-The incorporation of rubber has a considerable effect on the behavior of clay.

-Shear strength and maximum displacement increase as the percentage of rubber increases.

-The existence of the fiber in the granular skeleton prevents relative movement between the grains, thus creating additional friction.

-Shear tests showed an increase in the angle of internal friction and a decrease in cohesion after each increase in the percentage of addition, resulting in a transition from a cohesive to a granular state.

In short, the treatment of clays with reinforcements of rubbery origin not only creates an additional source to absorb certain quantities of these industrial wastes, but also improves the mechanical properties of the clay studied.

5 References

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