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Effects of fibrous rubberized waste on the geotechnical properties of clayey soil

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Abstract **–** Rubber waste is an environmental threat as it occupied more landfill spaces and pollutes soil, water, and air. The main goal of this paper is to investigate the possibility of using randomly distributed fibrous rubberized waste (RDFRW) obtained from scrap tires to reinforce clay soil. RDFRW is added to soil at different percentages of 0, 5, 1, 1.5, and 2% by weight of clay. The results obtained show that the inclusion of RDFRW in the clay will improve its geotechnical properties including, unconfined compressive strength, shear behavior, and load-capacity resistance. In addition to the technical benefits, using fibrous waste in geotechnical application help to make geo-environmentally material and reduce some quantities of such type of industrial waste.

Keywords – Rubber, waste, fibers, clay soil, reinforcement, strength

I. INTRODUCTION

One of the main challenges for geotechnical engineers was to improve the engineering properties of soils and/or to control the strains under existing structures. Soils are commonly stabilized by a chemical procedure using cementitious materials such as cement and lime or by mechanical mechanism incorporating reinforcements such as strips, sheets, grids, bars, or fibers [1,2]. Therefore, mechanical reinforcement can be performed by adding previously-oriented continuous elements as used in mechanically stabilized earth structures [3–5], or by incorporating aleatorily oriented discrete fibers [6]. For the first technique, shear tensile strength in zones surrounding the reinforcement increases, which creates shear plans at the inclusions and affects local as well as global stability of earth-based structures, especially when placing many layers of linear elements. However, in the second case discrete fibers randomly distributed reduce the formation of weak planes, which could increase the long-term stability of reinforced earth-based structures [7]. Reinforcing soils with discrete fibers has been increasingly investigated by researchers both in theory and in practice due to its advantages. In comparison with continuous reinforcements, randomly distributed fibers have several advantages including fibers that can be simply incorporated in soils, in much in the same way as lime, cement, and other additives; randomly distributed fibers provide an isotropic increase in the strength of fiber-reinforced soil and reduce the risk of the potential planes of weakness that can develop parallel to the continuous reinforcements [8].

Randomly distributed fibers can be classified by their constituted material many types of fibers are used by researchers for reinforcing both granular and cohesive soils such as polypropylene fibers [8,9], natural fibers [10], polyethylene terephthalate fibers [7], linen fibers [11], glass fibers [12] and rubber fibers [6]. addition, researchers [2,13] have indicated that fibers reinforced soils are more efficient at low confining pressure such as shallow foundations, retaining walls, and slopes.

Rubber wastes are considered one of the major waste problems due to their direct effect on the environment. Therefore, rubber waste material is not bio-degradable and can form a favorable environment for breeding vermin and mosquitoes [14–17]. In addition to that, its storage in landfills in high volumes could be a serious problem in case of eventual fire, due to its potential to generate toxic fumes. Although, the management of rubber wastes in civil engineering applications may help to preserve the natural resources and produce an eco-friendly material [18].

Furthermore, Balunaini et al. 2014 [19] reported that rubber waste can be recycled in several civil engineering applications such as embankment fill material, drainage material, vibration dampening material underneath railways, thermal insulation layer, and asphalt rubber paving layer. In addition to that, shredded rubber wastes were used as aggregates in concrete material as reported in several investigations [17,20–23].

The potentialities of using rubber waste reinforced soils as backfill material for geotechnical applications, such as highway embankments and retaining walls, were investigated by many studies [24–26]. In these works, authors have analyzed the effects of rubber particles on the engineering properties of soils. In addition, it has been reported in a previous investigation [6], that the shearing behavior of soils can be improved soil can be improved by adding rubberized fibers. They have reported that rubberized fibers increased the frictional angle and the maximum shear strength. They mentioned also that incorporating rubber fibers helped to introduce more ductility behavior to the soil. Most previous studies have been conducted on sandy soils, however, there is little available information in the literature on the behavior of clayey soils reinforced with such of type fibrous waste rubberized fibers. The objective of this work is to quantify the effects of rubber fibers on the behavior of clay soil. The fibers were incorporated in clay with different rates: 0.5; 1; 1.5 and 2% dry weight of clay. Many tests were used to characterize these effects including unconfined compressive strength, shear strength, and CBR.

II. Materials and Method

The soil used in this investigation was namely soil of Mouilha, locally available in the M'sila region, Algeria. Plasticity characteristics, physical and granulometric characteristics of the clay of Mouilha are listed in Table 1. As per USCS classification, this soil is classified as low plasticity clay soil. Rubber waste fibers provided by the Algerian company of Elastomeric Materials in Algiers. The specific gravity of fibers is 0.88. Its length is varied from 3 to 16 mm and its diameter is ranged between 0.2 and 0.5 mm. The aspect of rubber fibers used is shown in Figure 2.

To reduce the heterogeneity and the variability of samples, soil and fibers are previously mixed with dry soil in a container for 120 s, then water is added and the all ingredients are mixed again for 120 s. Specimens with dimensions 100 mm diameter and 200 mm of height were used for the compressive test. All samples were prepared with the optimum moisture content and maximum dry unit weight values of the proctor curve. For all mixes, the mean of three values is taken. Shear curves were developed by the direct shear tests (référence), despite the limitation of this test, it the common used in practice due to its simplicity.

Fig. 1. Aspect of rubber waste used

Table 1. Example of a table

Parameter	Plages de variation	Moyenne
Natural water content □nat (%)	10.23-10.32	10.275
Liquidity limit □L (%)	38,82-43,19	40.67
Plasticity limit □p (%)	18.77-21,21	19.90
Plasticity Index Ip	20.05-21,98	20.76
Blue de Methylene value VBS	6.36-7.33	6.79
Specific area (m2/g)	131.13 -153.75	142.44
Over 2 mm (%)	98.46-99.78	99.56
Over à 80 µm (%)	75.23-78.93	77.24
Over 2 µm (%)	20.56-23.68	22.18
Consistency index Ic	1.423-1.497	1.464

III. Results and Discussions

A. *CBR tests*

The relationships between the load on the plunger of the CBR test and its penetration for both reinforced and unreinforced soils are plotted in Figs. 1-2, for unsoaked and soaked conditions, respectively. As can be seen, the load-penetration response is simultaneously affected by the fiber content and the moist conditions. These results show that rubber fibers reinforced samples are more resistant to punching shear efforts as unreinforced soil, for both unsoaked and soaked conditions. But it should be noted that the effect of fibers is more significant for the unsaoked than the soaked conditions.

Fig. 3 shows the effect of rubber fibers on CBR ratios, it can be seen that all reinforced samples have CBR values higher than unreinforced samples. For example, the CBR ratio is changed from 67.68 to 98.28 when the soil is reinforced with 1% of fibers which represents 45% of improvement. For the same fiber content, the CBR ratio for soaked conditions is improved by 20%. Therefore, the best performance is obtained with samples reinforced with 0.5 and 1 % for soaked and unsaoked conditions, respectively.

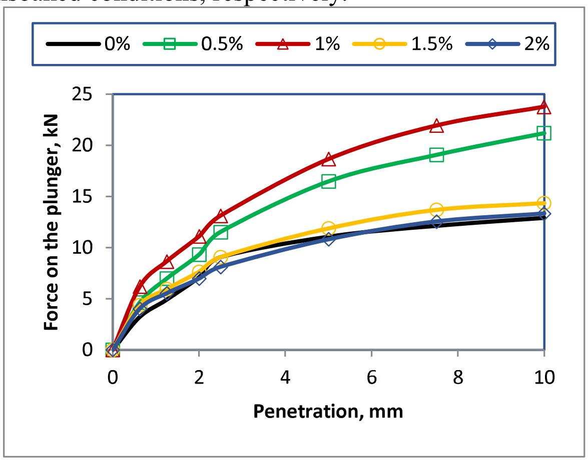


Fig. 2. Load-penetration curve of unsoaked samples.

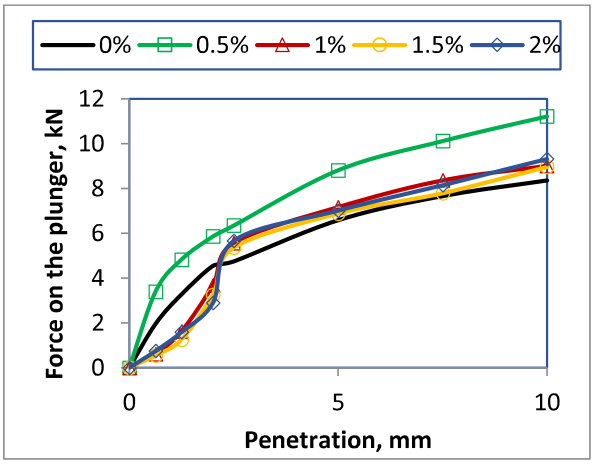


Fig. 3. Load-penetration curve of soaked samples.

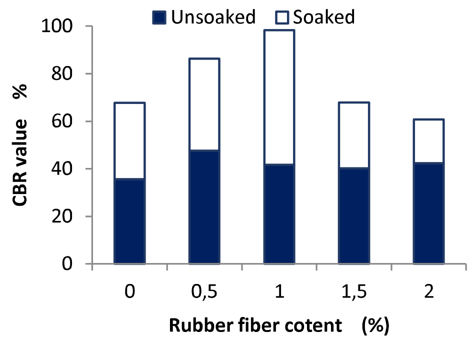


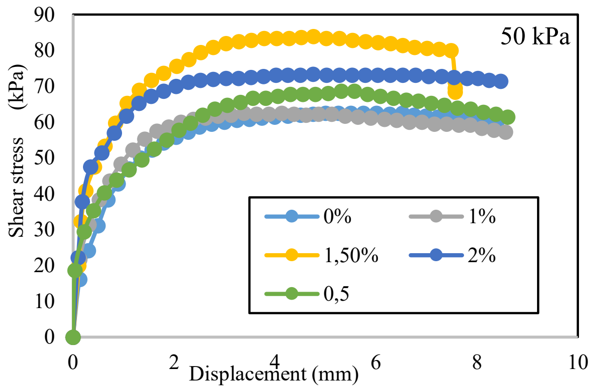
Fig. 4 Effect of rubber fiber addition on CBR value.

B. Shear stress curves

The effect of the incorporation of randomly distributed rubber fibers on the shear stress behavior is investigated by conducting direct shear tests. Despite the limitation of this test, it is the common procedure used to study the shear behavior of soils due to its simplicity, in comparison with the triaxial test. As the shear strength behavior of soils is related to the applied confining pressure, both reinforced and unreinforced soil samples are subjected to three normal stresses (50, 100, and 200 kPa).

The relationships between the shear stress and the horizontal displacements are shown in Figs. 4 and 5. It can be seen from the results that the stresses-displacements responses, for both reinforced and unreinforced soil, are affected simultaneously by rubber fibers content and by normal stress intensity applied during shearing. Shear stress test results curves show that the trends of behavior curves for both reinforced and unreinforced soil confirm typical responses of clay soils under shearing conditions. Therefore, deformations are developed gradually towards asymptotic values at high displacements corresponding to residual strengths beyond which there are no increases in shear stresses. On the other hand, it can be observed that the shear strength increased alongside normal stresses applied during shearing.

The local behavior of rubber fiber reinforced soil can be explained by the interaction between the soil particles and fibers during shear. Stresses transform from soil to fibers which put them in tension and consequently increases the tensile strength of reinforced soil and improve the global behavior of structures founded on fiber-reinforced soils.



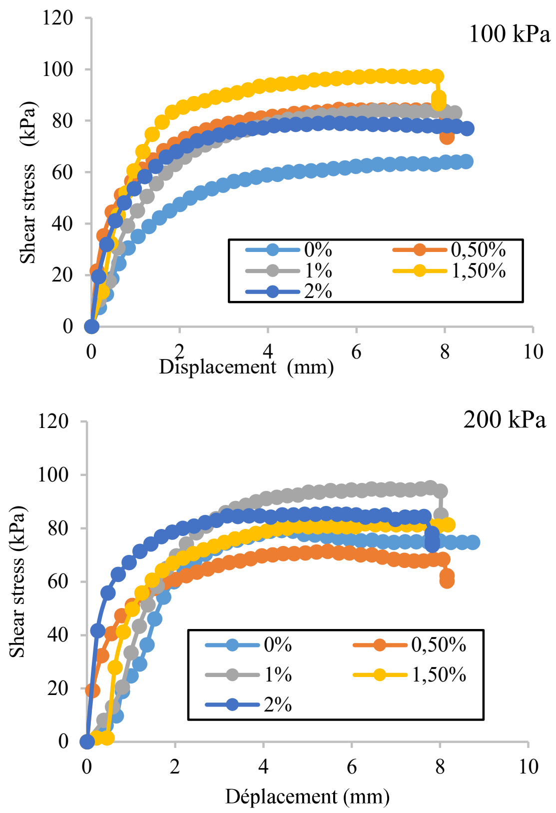


Fig. 5 Effect of rubber fiber on shear strength curves.

C. *Unconfined compressive strength*

From the results of the compression test on natural and fiber-reinforced soil specimens, it is clear that the existence of rubber fibers improves the compressive strength. But it is important to point out that the highest values of compressive strength are shown by the mix reinforced with 1% of the rubber fibers.

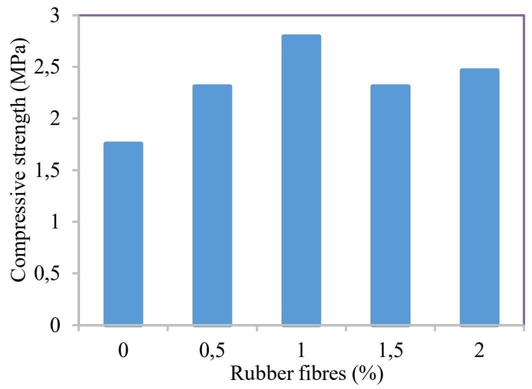


Fig. 6 Effect of rubber fiber addition on UCS.

IV. CONCLUSION

The feasibility of reinforcing the clay soil of Mouilha collected from the M'sila region, Algeria. by RDFRW waste is experimentally investigated in this paper. RDFRW is incorporated in the soil with various concentrations. The obtained results show that:

1. adding RDFRW to the soil improves the bearing capacity of clayey soil. The best value is obtained with soil reinforced by1% of RDFRW.
2. By incorporation RDFRW, the shear strength and unconfined compressive strength are improved. The best performances are obtained for soils reinforced by 1.5% and 1%, respectively. Therefore, adding RDFRW restricts the displacement rate which provides more ductility to the soil.

In addition to these finding, using rubber fibers in geotechnical applications makes a geo-environmentally material, and help both in circular economy and sustainability. Therefore, based on these results, rubber waste can be used to improve the geotechnical properties of soils which is very useful for some civil engineering applications such as shallow foundations, retaining walls, and slopes.

References

[1] D.H. Gray, A.M. Asce, H. Ohashi, Mechanics of Fiber Reinforcement in Sand, 109 (1983) 335–353.

[2] W. Shao, B. Cetin, L. Yadong, J. Li, L. Li, Experimental Investigation of Mechanical Properties of Sands Reinforced with Discrete Randomly Distributed Fiber, Geotech. Geol. Eng. 32 (2014) 901–910. https://doi.org/10.1007/s10706-014-9766-3.

[3] A. Meddah, M. Sahli, S. Safer, Etude de l'effet de la rugosité des renforcements sur le comportement des massifs en terre armée, in: Journées d'étude Génie Civ., M'sila University, Algeria, 2015: pp. 54–59.

[4] A. Meddah, M. Sahli, Pullout behavior of steel reinforcements used for mechanically stabilised structures, Min. Sci. 28 (2021) 47–58. https://doi.org/10.37190/msc212804.

[5] M. Khemissa, S. Safer, … M.S.-P. of the, undefined 2004, Etude des performances de quelques éléments de terre armée, Researchgate.Net. (2004). https://www.researchgate.net/profile/Mohamed-Khemissa/publication/291347418_Etude_des_performances_de_quelques_elements_de_terre_armee/links/56a159d208ae27f7de2667aa/Etude-des-performances-de-quelques-elements-de-terre-armee.pdf (accessed October 13, 2021).

[6] Abdelaziz Meddah;, Karima Merzoug, Feasibility of using rubber waste fibers as reinforcements for sandy soils, Innov. Infrastruct. Solut. 2:5 (2017). https://doi.org/10.1007/s41062-017-0053-z.

[7] E. Botero, A. Ossa, G. Sherwell, E. Ovando-Shelley, Stress-strain behavior of a silty soil reinforced with polyethylene terephthalate (PET), Geotext. Geomembranes. 43 (2015) 363–369. https://doi.org/10.1016/j.geotexmem.2015.04.003.

[8] C.-S. Tang, B. Shi, L.-Z. Zhao, Interfacial shear strength of fiber reinforced soil, Geotext. Geomembranes. 28 (2010) 54–62. https://doi.org/10.1016/j.geotexmem.2009.10.001.

[9] E. Ibraim, A. Diambra, A.R. Russell, D. Muir Wood, Assessment of laboratory sample preparation for fibre reinforced sands, Geotext. Geomembranes. 34 (2012) 69–79. https://doi.org/10.1016/j.geotexmem.2012.03.002.

[10] J. Maity, B.C. Chattopadhyay, S.P. Mukherjee, Behaviour of Different Types of Sand Randomly Mixing with Various Natural Fibers, J. Inst. Eng. Ser. A. 93 (2012) 97–104. https://doi.org/10.1007/s40030-012-0014-7.

[11] S. V. Krishna Rao, A.M.A. Nasr, Laboratory Study on the Relative Performance of Silty-Sand Soils Reinforced with Linen Fiber, Geotech. Geol. Eng. 30 (2012) 63–74. https://doi.org/10.1007/s10706-011-9449-2.

[12] A. Ateş, Mechanical properties of sandy soils reinforced with cement and randomly distributed glass fibers (GRC), Compos. Part B Eng. 96 (2016) 295–304. https://doi.org/10.1016/j.compositesb.2016.04.049.

[13] A. Meddah, K. Merzoug, Feasibility of using rubber waste fibers as reinforcements for sandy soils, Innov. Infrastruct. Solut. 2 (2017) 5. https://doi.org/10.1007/s41062-017-0053-z.

[14] R. Siddique, T.R. Naik, Properties of concrete containing scrap-tire rubber--an overview., Waste Manag. 24 (2004) 563–9. https://doi.org/10.1016/j.wasman.2004.01.006.

[15] A. Meddah, M. Beddar, A. Bali, Experimental study of compaction quality for roller compacted concrete pavement containing rubber tire wastes, in: Sustain. Eco-Efficiency, Conserv. Transp. Infrastruct. Asset Manag., CRC Press, 2014: pp. 273–278. https://doi.org/doi:10.1201/b16730-41.

[16] A. Meddah, M. Beddar, A. Bali, Use of shredded rubber tire aggregates for roller compacted concrete pavement, J. Clean. Prod. 72 (2014) 187–192. https://doi.org/10.1016/j.jclepro.2014.02.052.

[17] A. Meddah, Characterization of roller compacted concrete contaning rubber-tire wastes, National Polytechnic school of Algiers, 2015.

[18] A. Meddah, M. Beddar, A. Bali, Use of shredded rubber tire aggregates for roller compacted concrete pavement, J. Clean. Prod. 72 (2014) 187–192. https://doi.org/10.1016/j.jclepro.2014.02.052.

[19] U. Balunaini, S. Yoon, M. Prezzi, R. Salgado, Pullout Response of Uniaxial Geogrid in Tire Shred-Sand Mixtures, Geotech. Geol. Eng. 32 (2014) 505–523. https://doi.org/10.1007/s10706-014-9731-1.

[20] E. Güneyisi, M. Gesoğlu, T. Özturan, Properties of rubberized concretes containing silica fume, Cem. Concr. Res. 34 (2004) 2309–2317. https://doi.org/10.1016/j.cemconres.2004.04.005.

[21] K. Jingfu, H. Chuncui, Z. Zhenli, Strength and shrinkage behaviors of roller-compacted concrete with rubber additives, Mater. Struct. 42 (2008) 1117–1124. https://doi.org/10.1617/s11527-008-9447-x.

[22] O. Onuaguluchi, D.K. Panesar, Hardened properties of concrete mixtures containing pre-coated crumb rubber and silica fume, J. Clean. Prod. 82 (2014) 125–131. https://doi.org/shao.

[23] B.S. Thomas, R.C. Gupta, Long term behaviour of cement concrete containing discarded tire rubber, J. Clean. Prod. 102 (2015) 78–87. https://doi.org/10.1016/j.jclepro.2015.04.072.

[24] V. Cecich, L. Gonzales, J. Williams, K. Reddy, Use of Shredded Tires As Lightweight Backfill, Waste Manag. Res. 14 (1996) 433–451. https://doi.org/10.1177/0734242X9601400503.

[25] S. Yoon, M. Prezzi, N.Z. Siddiki, B. Kim, Construction of a test embankment using a sand-tire shred mixture as fill material, Waste Manag. 26 (2006) 1033–1044. https://doi.org/10.1016/j.wasman.2005.10.009.

[26] D. Kyser, N. Ravichandran, M. ASCE, Properties of Chipped Rubber Roofing Membrane and Sand Mixtures for Civil Engineering Applications, J. Build. Eng. 7 (2016) 103–113. https://doi.org/10.1016/j.jobe.2016.05.008.

[27] NF P 94 052, Limites d'Atterberg, (1993).

[28] N.P. 94 068, VBS, (1998).