MECHANICAL AND PHYSICAL PROPERTIES OF TUFF BLOCKS REINFORCED BY CARDBOARD

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Abstract - With the development of social, economic and environmental issues in today's society, the demand for sustainable building materials and the use of natural materials at low cost is growing. This study investigated the properties of tuff blocks stabilized by cardboard, it also confirmed the use of tuff as construction materials. Laboratory experiments include the compressive strength, the tensile strength and water absorption were conducted on soil blocks made with tuff soil and enhanced with cardboard. The results showed that increasing the percentage of cardboard on the tuff is beneficial for improving mechanical strength.

Keywords : Tuff block , Cardboard, Mechanical and Physical Properties.

Résumé - Avec le développement des enjeux sociaux, économiques et environnementaux dans la société actuelle, la demande de matériaux de construction durables et l'utilisation de matériaux naturels à faible coût est en croissance. Cette étude a vérifié les propriétés des blocs de tuf stabilisés par du carton. Il a été également confirmé l'utilisation du tuf comme matériau de construction. Les expériences en laboratoire incluent la résistance à la compression, la résistance à la traction, la vitesse de propagation du son et l'absorption d'eau. Elles ont été menées sur des blocs de sol en tuf et renforcés avec du carton. Les résultats ont montré que l'augmentation du pourcentage de carton sur le bloc de tuf contribue à améliorer sa résistance mécanique.

Mots clés : Bloc de tuf, Carton, Propriétés mécaniques et Physiques.

1-Introduction

Earth has been widely utilized as a building material since ancient times [1]. Again, earth materials have attracted people's attention attributing to its ecological benefits and widespread regional adaptability [3–4].At present, there are many earth buildings in many countries due to the improvement in people's attention to the environment, Meanwhile, the application of low-cost excellent thermal performance, and easy to use local materials and sustainable materials in construction has become the focus of research [5, 6].

Earth materials can be used as a building material in many ways, such as earth blocks and rammed earth. However, compared with industrial building materials like concrete, they have an apparent deficiency in physical property, mechanical property, and durability [7, 8]such as poor dimensional stability, low strength, erosion due to wind or rain, and especially, low resistance to dynamic actions . Furthermore, for improving properties of earth and to facilities for uses in recent times, there has been an attention to the use of different materials and various manufacturing processes as stabilizers.

This paper presents experimental results of investigations done on the use of tuff, and it reports the attempts made to understand the role of cardboard as a stabilizer in improving the properties of the tuff block and reducing the cost of the blocks.

The use of tuff as a building material poses special challenges to science and technology, the challenge of developing new technologies to facilitate the use of tuff in the production of building materials. According to the literature, these materials cover an area of about 300 000 km^2 in Algeria [9]. The use of local tuff is more beneficial for the population as tuff is locally available in abundance and economic benefits .[10]

This research is a part of the study valorizing the tuffs of the Laghouat region by their transformation into stabilized tuffs blocks, including the search for new materials that are efficient and sustainable and with the least cost, which could solve an environmental, economic problem and technical in construction [11]. This paper is about trying to treat the tuff with cardboard, and tested on compressive strength, tensile strength and water absorption.

2- Materials & Methods

2.1- Materials

- Soil : Two different soils were used in this investigation ,which were collected from the Laghouat region in central Algeria. The first was tuff, beige in colour, extracted from a deposit dating from the Quaternary to the Cretaceous as a result of a number of exchanges by dissolution and precipitation. It is often used in road construction. It is a sedimentary limestone rock, friable, soft and porous.

The granular composition of the soil is determined through two tests: Grain size analysis and sedimentometry, according to NF P94-056 and NF P 94-057 [12] (Norme AFNOR) successively. The test results are presented in Fig. 1, and Test Proctor Fig .2, these results have allowed us to classify tuff as a sandy soil of very calcareous

Cardboard: material like very thick , stiff paper, usually pale brown in colour, used especially for making boxes. [13]

Water :The water is drinking water having a temperature of 20 ± 2 °C. Its quality conforms to the requirements of NFP 18-404 standard.

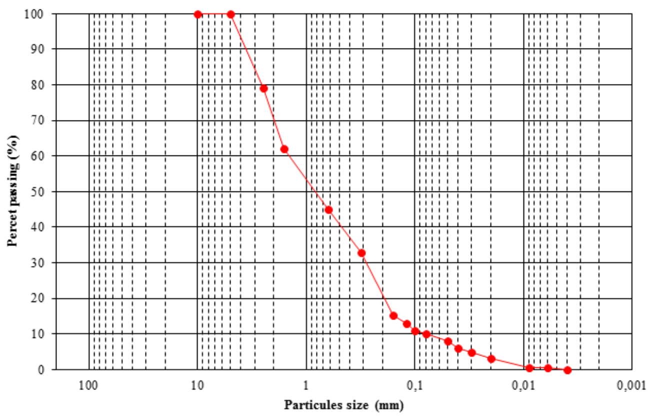

Figure 1 : Grading curve of the soil used.

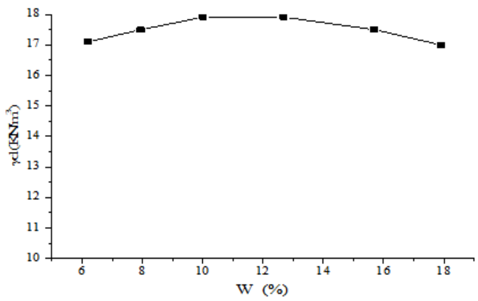

Figure 2 : Proctor curves of the soil used.

Table 1 : Properties of soil used

Test	parameter	Tuff
Atterberg limits NF P 94-051	LL(%) PL(%) PI(%)	33.2 NM NM
Sand equivalent NF P 18-598	SE (%) SE_t (%)	NM 19.3
Methylene blue test, NF P 94-068	MB (%)	1
Proctor test NF P 94-093	w_{OPN} (%) γ_{OPN}(kN/m³)	12.7 17.9

2.2- Methods

2.2.2-Specimens preparation

The series of tests was carried out to study tuff blocks and the influence of the physical stabilization by fiber (cardboard addition 2%, 4%, 6%) by mass relative to soil on mechanical and physical properties (compressive strength NF P 98-230-2 (Afnor, 1993) , tensile strength ASTM 496-96 (ASTM 1996) [14] and speed sound NF P 18-418 (Afnor, 1989) [12] and water absoption of the various mixtures.

Samples for testing are prepared by drying the soil in an oven for 24 hours at 105 ° C, the soil is initially mixed dry and then mixed with water. When making the sample, special attention is paid to the formation of lumps. For this, the kneading has been carried out manually several times by screening in a sieve 5 mm in diameter, in order to have a homogeneous mixture. The mixture, with and without additives, were statically compacted with the optimum water content and the maximum dry density of the normal Proctor test in a double piston cylindrical mold, 50 mm in diameter and 100 mm in height.

Note: We proceed to the addition of fiber 'cardboard' by mixing manually with tuff after immersion in water until it reaches total saturation.

Figure 3 : Mould used for the manufacture of tuff blocks

Figure 4: Press used for compacting and crushing test

Figure 5: Tuff blocks reinforced with cardboard

3-Results and Discussion.

3.1- Compressive and Tensile strength test

The addition of fibers to tuff block caused an increase in compressive strength, tensile strength with the increase of the fiber content .The effect of a change in the fiber content in the dry compressive strength and tensile strength of tuff block is illustrated in Fig. 6 and 7. The compressive and tensile strength of reinforced blocks with fibers recorded higher strength results compared to the unreinforced blocks. From the results, it can be noticed better result was obtained by using 6 %of cardboard, the compressive strength for 6% of cardboard increases a rate in the order of 65 % compared with the mixture without fibers.The results achieved could not satisfy the minimum strength requirement of 3 MPa set by CNERIB (1991) [15], but it was stimulating and encouraging .
Relevant published studies on CEBs have shown that the addition of natural fibres reduces the size of shrinkage cracks and improves durability and tensile strength [16, 17, 18] , and this study confirmed so that the greater the amount of cardboard, the tensile strength increases Fig .7.

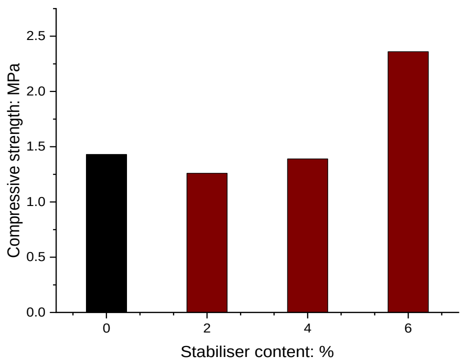

Figure 6 : Compressive strength of blocks depending on the dosage of cardboard.

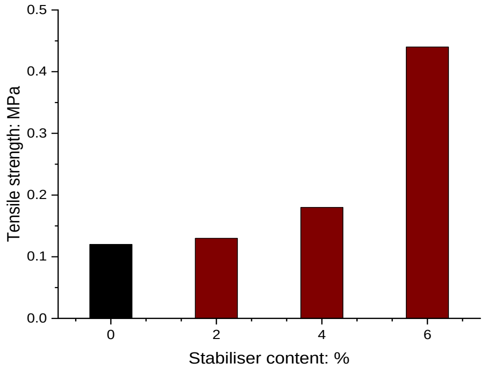

Figure 7 : Tensile strength of blocks depending on the dosage of cardboard.

3.2-Water Absorption

- Capillary absorption

Fig.9 shows that the capillary absorption decreases when increasing the fiber content.. The results are more than 2.5% value limit specified by the Uniform Building Code, USA [19]

Figure 8 : The test pieces during the test.

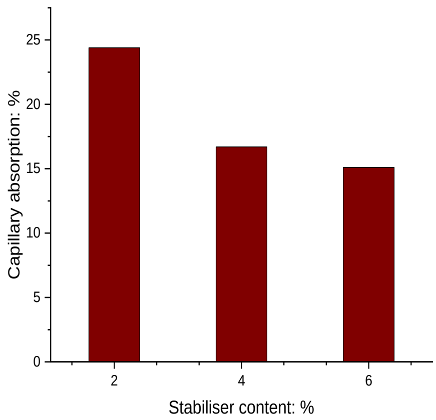

Figure 9 : Influence of cardboard content on the absorption of block tuff.

-Total Water Absorption

In our study, the test blocks were submerged for 24 hours until 28 days, Fig.10. The absorption of water is greatly influenced by the porosity and surface texture of particular material. The specimen with and without stabilizer immersed in water, within minutes it began to disintegrate, few minutes had collapsed completely, so the value of the total water absorption (TWA) of blocks no measurable.

Figure 10 : The test pieces during the test.

4-Conclusion

This research is a part of the study valorizing the tuffs of the Laghouat region by their transformation into stabilized tuff blocks. This paper is about trying to treat the tuff with a cardboard for improving the weak point of tuff and for ease of use in construction. Based on the results of this experimental study, the following conclusions can be drawn:

- The collapse completely of blocks resulting in a decrease in the cohesion between soil particles and cardboard.

- Reinforced tuff block increased compressive strength and improved the tensile strength, but the weak of this stabilizer was low water resistance. To overcome these problems, treatment with hydraulic binders is necessary .

- Tuff and cardboard materials were applied for the fabrication earth block or as construction material was stimulating and encouraging especially when uses in the arid region .

References

[1] Maniatidis ,V. and Walker , P.; Structural capacity of rammed earth in compression., *Journal of Materials in Civil Engineering*, vol. 20, no. 3, pp. 230–238, 2008.

[2] Achenza ,M. and Fenu, L., *On Earth Stabilization With Natural Polymers For Earth Masonry Construction*., Materials and Structures, vol. 39, no. 1, pp. 21–27, 2006.

[3] Miccoli, L., Oliveira , D.V., Rui , A.S. et al., *Static Behaviour Of Rammed Earth: Experimental Testing And Finite Element Modelling*., Materials and Structures, vol. 48, no. 10, pp. 3443–3456, 2015.

[4] Pacheco-Torgal ,F. and Jalali, S., *Earth Construction : Lessons From The Past For Future Eco-Efficient Construction*., Construction and Building Materials, vol. 29, no. 4, pp. 512–519, 2012.

[5] Sturm, T., Ramos, L. F and Lourenço, P. B., *Characterization Of Dry-Stack Interlocking Compressed Earth Blocks*., Materials and Structures, vol. 48, no. 9, pp. 3059–3074, 2015.

[6] Cabeza, L. F., Barreneche, C., MirÓ , L. et al., *Low Carbon And Low Embodied Energy Materials In Buildings: A Review*., Renewable and Sustainable Energy Reviews, vol. 23, pp. 536–542, 2013.

[7] Mansour , M.B., Jelidi , A., Cherif, A.S. et al., *Optimizing Thermal And Mechanical Performance Of Compressed Earth Blocks (CEB)*., Construction and Building Materials, vol. 104, pp. 44–51, 2016.

[8] Miller, N.M. and Tehrani, F.M., *Mechanical Properties Of Rubberized Lightweight Aggregate Concrete*., Construction and Building Materials, vol. 147, pp. 264–271, 2017.

[9] Goual, I., *Comportement mécanique et hydrique d'un mélange de tuf et de sable calcaire de la région de Laghouat : application en construction routière*., Doctoral thesis, University of the Telemcen, 2012.

[10] Benguettache, K., Goual, I. and Gueddouda , M.K., *Effet of Stabiliser tupe on the physical and mechanical properties of tuff material*., Proceeding of the institution of civil engineers –construction materials,https://doi.org/10.1680/jcoma.18.00091 14/04/2020

[11] Benguettache , K., *Etude du comportement thermo-hydro-mécanique de briques de tufs stabilisés BTS*., Doctoral thesis, University of Laghouat., (en cours).

[12] Afnor, Paris, France :
Afnor (1981) NF P 18-404 : Standards: Bétons-Essais d'étude, de convenance et de contrôle - Confection et conservation des éprouvettes
Afnor (1989) NF P 18-418, Standard: Béton - Ausculatation sonique - Mesure du temps de propagation d'ondes soniques dans le béton.
Afnor, Paris, France (in French). Afnor (1999a) NF P 94-056/057 : Détermination de la granulométrie par tamisage/Détermination de la granulométrie par sédimentometrie, Afnor, Paris, France (in French).
Afnor (1999c) NF P 94-093, 078: Reconnaissance et essais – Détermination des références de compactage d'un matériau – Essai Proctor normal. Essai Proctor modifié. Afnor, Paris, France (in French).
Afnor (1993) NF P 98-230-2. Compressive strength test. Afnor, Paris, France (in French).

[13] https://dictionary.cambridge.org/fr/dictionnaire/anglais/cardboard17:20-20/09/2018

[14] ASTM., 496-96: *Standard test method for splitting tensile strength of cylindrical concrete specimens*. ASTM International, 1996.

[15] CNERIB., *Proceedings Of Maghreb In Symposium On Development Of Construction With Local Materials*: MATLOC 91, 3–5 December 1991, Biskra, CNERIB, Ministry of Housing, Algeria, p. 209.

[16] Coutts, RSP., Ni Y., *Autoclaved Bamboo Pulp Fibre Reinforced Cement*., Cem Concr. Compos;17(2):99–106,1995.

[17] Filho, RDT., Scrivener, K., England ,Gl and Ghavami, K., *Durability Of Alkali-Sensitive Sisal And Coconut Fibres In Cement Mortar Composites*., Cem. Concr. Compos.; 22(2):127–43,2000.

[18] Ghavami K, Filho RDT, Barbosa NP. *Behaviour Of Composite Soil Reinforced With Natural Fibres.* Cem. Concr. Compos.; 21(1):39–48, 1999.

[19] Ziegler, S., Leshchinsky, D., Ling, HL and Perry ,EB., *Effect of short polymeric fibres on crack development in clays*., Soils Found; 38(1):247–53,1998.

[20] Houben, H. and Guillaud , H., *Traité de construction en terre*., Marseille: Parenthèses, 1989.