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**The 4th Edition of EUROMAGH BIOCOSCOMPOSITES Conference
(EUROMAGH 2023)**

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Effect of sodium bicarbonate treatment on the mechanical properties of compacted earth brick (CEB) reinforced with red algae fibers

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1. INTRODUCTION

The incorporation of natural fibers in building materials has become a necessity in the sustainable development approach for the construction industries. Several studies have proposed treatments to improve the structural and morphological properties of natural fibers prior to their incorporation into building materials [1]. Alkaline treatment with sodium hydroxide (NaOH) is the most commonly used. Generally, it contributes to a partial removal of non-cellulosic compounds (lignin, hemicellulose, wax, etc.) present in the structure of the fibers. As a result, the mechanical properties were improved due to the improvement of the adhesion properties of the fibers after treatment [1]. The objective of this work is to evaluate the effect of incorporating *Gelidium sesquipedale* red algae fibers chemically treated with sodium bicarbonate solution on the mechanical properties of compacted earth bricks (CEB). This treatment has often been adopted to treat natural fibers for reinforcing polymer matrix composites [2]. However, to the best of our knowledge, no studies have been conducted with earth-based composites. In a previous study [3], it was previously shown that the introduction of raw algae fibers did not improve the mechanical properties of CEB. However, a content of 1.5% by mass could be effective. In order to improve the performance of CEB, it is recommended to modify and treat the surface of the algae fiber to improve its adhesive properties and decrease its hydrophilic properties. For this purpose, the algae fibers were treated with a sodium bicarbonate (NaHCO_3) solution at 10% mass concentration for different times (24, 72 and 120 h).

2. MATERIALS AND METHODS

2.1 Treatment of algae fibers

The algae fibers used in this study were obtained from the industrial processing of red *Gelidium Sesquipedale* algae for agar production in Kenitra city, Morocco. The algae fibers are immersed in 10% by mass solutions of sodium bicarbonate (NaHCO_3) at different immersion times: 24h, 72h and 120h at room temperature. After each treatment, a rinse with water is performed, then the fibers are dried in the oven at 60°C for 24 hours.

2.2 Production and characterization of CEB

The earth mix used consists of 60% clay, 28% sand and 12% porphyry. In a recent study [4], Atterberg limit tests (EN ISO 17892-12) and the plunger penetration test (EN 1015-4) with a modification of the surcharge were performed to determine the consistency suitable for compaction forming. The manufacturing water content of the CEB must be below the plastic limit (PL=20%) for the mixture to be suitable for compaction forming and the plunger penetration with an overload of 1 kg must have a value of 8 mm. In this study a similar approach was taken to investigate the effect of adding 1.5% by mass of the raw and treated fibers on the manufacturing water content and plasticity of the earth mix in fresh state. The earth mix

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containing the raw fibers has a plasticity index of 23%. The mechanical strengths of the CEB (compressive and flexural) were measured in the hardened state (on average 28 days). The formulations are prepared by adding algae fibers to the earth mix for dry mixing for 1 minute, then the water is added until the mixture is homogenized. After mixing, the moist material was statically compacted in a prismatic mould of dimensions 22×11×7.5 cm and compacted with the Mecopress machine at pressure level of 12 MPa. After demolding, the bricks are covered with a plastic film for 24 hours in order to ensure its water content homogeneity, its sealing and avoid rapid drying, then the bricks are dried by exposure to air ($T = 20 \pm 2^\circ\text{C}$, Relative Humidity (RH) = $50 \pm 10\%$) until reaching constant mass.

3. MAIN RESULTS

In order to evaluate the efficiency of sodium bicarbonate treatment and to optimize the time of this treatment on the algae fibers, fresh state tests of the different mixtures containing raw and treated fibers were performed. The mechanical behavior of the CEB reinforced with raw and treated fibers was evaluated in the hardened state.

3.1 Fresh state characterization: Atterberg limits and plunger penetration with surcharge

Increasing the treatment time of the algae fibers significantly decreases the plasticity of the earth mix. The mixtures containing the treated fibers at different times represent a low plasticity that does not exceed a PI value of 21%, a decrease of 13% compared to the mixtures containing the untreated fibers. A relative decrease of 6% in the manufacturing water content of the CEB with the addition of the treated algae fibers was found compared to the CEB containing the raw fibers. This decrease may be due to the reduction in hydrophilic properties of the algae fibers with the treatment [2].

3.2 Characterization of CEB in the hardened state: Compressive and flexural strength

The CEB reinforced with raw fibers, have a compressive strength of 4.07 MPa and a flexural strength of 0.78 MPa. The incorporation of treated algae fibers increases the mechanical resistance. Indeed, the CEB reinforced with the treated fibers during the different periods of 24h, 72h, and 120h have a compressive strength of 4.69 MPa, 5.01 MPa, and 4.57 MPa, and a flexural strength of 0.84 MPa, 0.88 MPa, and 0.81 MPa respectively. The CEB reinforced with the fibers treated for 72h show a maximum improvement of more than 23% in mechanical strengths compared to the CEB reinforced with the raw fibers. This increase in strength can be attributed to the increase in fiber strength after sodium bicarbonate treatment. However, after 72 hours of treatment, the mechanical strengths of the CEBs progressively decrease for the CEBs containing algae fibers treated for 120h. This decrease in strength of CEB incorporating treated fibers beyond 72 h is possibly attributed to excessive exposure of the fibers to the sodium bicarbonate solution [2], and possibly due to excessive removal of hemicellulosic compounds, causing fiber degradation and generation of a smooth fiber surface [5].

4. CONCLUSION

From the results of this study, it can be concluded that: (i) the addition of the treated algae fibers significantly decreased the plasticity of the earth mix, as well as the manufacturing water content of the CEB. (ii) The treatment of the fibers with sodium bicarbonate improved the mechanical properties of the CEBs compared to the CEBs containing the raw fibers (iii) The treatment time of 72h represents the optimum time to treat the algae fiber in order to obtain good mechanical properties of the CEB and better fiber/matrix interfacial adhesion.

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