



Mechanical Performance of Compacted Earth Bricks (CEB) Incorporated by Raw and Treated Red Algae Fibers “Gelidium Sesquipedale”

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| Corresponding Author | Family Name | Talibi |
| | Particle | |
| | Given Name | Soukayna |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | Univ. Artois, IMT Nord Europe, Junia, Univ. Lille, ULR 4515, Laboratoire de Génie Civil et géo-Environnement (LGCgE) |
| | Address | 62400, Béthune, France |
| | Division | Laboratoire des Matériaux innovants, Energie et Développement Durable (IMED-Lab) |
| | Organization | Univ. Cadi Ayyad |
| | Address | Marrakech, Morocco |
| | Email | soukayna.talibi@gmail.com |
| Author | Family Name | Page |
| | Particle | |
| | Given Name | Jonathan |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | Univ. Artois, IMT Nord Europe, Junia, Univ. Lille, ULR 4515, Laboratoire de Génie Civil et géo-Environnement (LGCgE) |
| | Address | 62400, Béthune, France |
| | Email | |
| Author | Family Name | Djelal |
| | Particle | |
| | Given Name | Chafika |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | Univ. Artois, IMT Nord Europe, Junia, Univ. Lille, ULR 4515, Laboratoire de Génie Civil et géo-Environnement (LGCgE) |
| | Address | 62400, Béthune, France |
| | Email | |

| | | |
|--------------------------------|--|--|
| | Email | |
| Author | Family Name | Saâdi |
| | Particle | |
| | Given Name | Latifa |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | Laboratoire des Matériaux innovants, Energie et Développement Durable (IMED-Lab) |
| | Organization | Univ. Cadi Ayyad |
| | Address | Marrakech, Morocco |
| | Email | |
| Abstract | <p>Red seaweed is widely available worldwide and its exploitation for the production of agar products has become an important industry in recent years. In Morocco, the industrial processing of red seaweed generates a large amount of algae fibers waste, which is a source of serious environmental problems. The main objective of this work is to valorize this algae fibers of Moroccan origin as a reinforcement of compacted earth bricks (CEB). These fibers were added to CEB at various ratios ranging from 0.5 to 3% by weight. The introduction of the fibers significantly increases the plasticity of the earth mixture in the fresh state. However, the algae fibers do not significantly alter the manufacturing water content of the CEB. In the hardened state, the inclusion of algae fibers leads to a significant decrease in mechanical properties, is probably due to the voids created by the algae fibers inside the matrix, which leads to poor fiber/matrix adhesion. In this regard, to enhance the mechanical properties of the CEB, various treatments were explored: pre-saturation of the fibers, alkaline treatment by sodium bicarbonate, and double coating treatment (linseed oil and metakaolin). Raw and treated algae fibers were incorporated into CEB with an addition ratio of 1.5% by weight. Compared to the untreated fibers, the pre-saturated fibers show a slight improvement of more than 5% in mechanical strengths. However, the alkali treated and double coated fibers provide a significant improvement of more than 20% in the mechanical strengths of the CEB.</p> | |
| Keywords (separated by '-') | Pre-saturation - Alkali treatment - Double coating treatment - Algae fibers - Compacted earth bricks - Mechanical properties | |



Mechanical Performance of Compacted Earth Bricks (CEB) Incorporated by Raw and Treated Red Algae Fibers “*Gelidium Sesquipedale*”

Soukayna Talibi^{1,2}(✉), Jonathan Page¹, Chafika Djelal¹, and Latifa Saâdi²

¹ Univ. Artois, IMT Nord Europe, Junia, Univ. Lille, ULR 4515, Laboratoire de Génie Civil et géo-Environnement (LGCgE), 62400 Béthune, France
soukayna.talibi@gmail.com

² Laboratoire des Matériaux Innovants, Energie et Développement Durable (IMED-Lab), Univ. Cadi Ayyad, Marrakech, Morocco

Abstract. Red seaweed is widely available worldwide and its exploitation for the production of agar products has become an important industry in recent years. In Morocco, the industrial processing of red seaweed generates a large amount of algae fibers waste, which is a source of serious environmental problems. The main objective of this work is to valorize this algae fibers of Moroccan origin as a reinforcement of compacted earth bricks (CEB). These fibers were added to CEB at various ratios ranging from 0.5 to 3% by weight. The introduction of the fibers significantly increases the plasticity of the earth mixture in the fresh state. However, the algae fibers do not significantly alter the manufacturing water content of the CEB. In the hardened state, the inclusion of algae fibers leads to a significant decrease in mechanical properties, is probably due to the voids created by the algae fibers inside the matrix, which leads to poor fiber/matrix adhesion. In this regard, to enhance the mechanical properties of the CEB, various treatments were explored: pre-saturation of the fibers, alkaline treatment by sodium bicarbonate, and double coating treatment (linseed oil and metakaolin). Raw and treated algae fibers were incorporated into CEB with an addition ratio of 1.5% by weight. Compared to the untreated fibers, the pre-saturated fibers show a slight improvement of more than 5% in mechanical strengths. However, the alkali treated and double coated fibers provide a significant improvement of more than 20% in the mechanical strengths of the CEB.

Keywords: Pre-saturation · Alkali treatment · Double coating treatment · Algae fibers · Compacted earth bricks · Mechanical properties

1 Introduction

Earth-based building materials are generally considered economical, environmentally friendly, and available in abundance [1]. However, these materials still have relatively low mechanical strengths compared to conventional building materials. Several techniques have been adopted to improve the properties of these materials: stabilization

with a hydraulic binder (cement or lime) [2, 3] or reinforcement with natural fibers [4, 5]. Indeed, the incorporation of natural fibers in the earth-based matrix improves the mechanical and thermal properties. Nevertheless, the water sensitivity of the biocomposite and the biodegradation of the natural fibers are issues that still need to be resolved in order to improve the quality of raw earth building materials. The search for new natural fibers is still being undertaken by many researchers.

Millogo et al. studied the reinforcement of compacted earth blocks (CEB) with two lengths (30 and 60 mm) and different contents of kenaf fibers (0.2 to 0.8% by weight) [5]. The best properties were obtained with the addition of 0.4% of kenaf fibers, allowing to increase the compressive strength by about 16% for short fibers (30 mm) and 8% for long fibers (60 mm). In the study conducted by Preneron et al. a comparison of three types of plant fibers (barley straw, hemp, and corn) with an addition content of 3% and 6% by weight was performed [6]. The addition of these fibers decreased the compressive and flexural strengths of CEB. This behavior was attributed to the hydrophilic character of the fibers which increases the porosity inside the matrix during the drying of CEB, which leads to a poor fiber/matrix adhesion. Several studies have suggested surface treatments of the fibers to improve the mechanical performance of CEB. Ajouguim et al. incorporated alkali treated Alfa fibers with an addition ratio of 1% by weight in CEB [7]. The results showed an improvement of 50% in the flexural strength and 30% in the compressive strength of CEB. In addition, the treatment modifies the surface roughness and thus enhance the adhesion of fibers in the clay matrix. The organic coating treatment could also be used to reduce the hydrophilic character of the fiber [8]. However, this type of coating leads to a reduction in fiber/matrix adhesion and therefore a decrease in short-term performance [9]. There is also the mineral coating treatment. Its objective is to chemically isolate the fibers by minimizing exchanges with the matrix and reducing the rate of water absorption. Thus, the mineral coating creates a fiber/matrix interfacial zone that prevents fiber degradation over time [7]. A new hybrid treatment (organic coating/mineral coating) was explored in the study of Silva et al. [10]. They showed that the treatment of coir fibers leads to an improvement in the mechanical strengths and durability of polymer-based composites.

In Morocco, red algae of the type “*Gelidium sesquipedale*” are exploited for the extraction of agar-agar by the company SETEXAM (Kenitra, Morocco). This industry generates a large amount of algae fibers waste which causes environmental problems. Algae fibers have been used in several fields as: substitution of wood for paper manufacturing [11], fertilizer in corn cultivation [12], and reinforcement in nanopolymers [13]. To our knowledge, there is no study had been conducted for its application in the field of raw earth construction, hence the originality of this study. The objective of this work is to study the effect of introducing various addition rates of red algae fibers, ranging from 0.5% to 3% by weight, on the rheological and mechanical properties of compacted earth bricks (CEB). After determining the optimal addition rate of the algae fibers, a pre-saturation of the fibers and two surface treatments (alkaline and double coating) of the algae fibers were performed to improve the mechanical performance of the CEB. Alkaline treatment with sodium bicarbonate has often been adopted to treat natural fibers for reinforcing polymer matrix composites [10]. However, to our knowledge, no studies have been conducted with earth-based composites. Double coating treatment (linseed

oil/metakaolin) has been carried out to reduce the water absorption capacity of algae fibers and improve their durability in earth-based composites. To evaluate the effectiveness of these treatments, CEB containing treated fibers are performed. The mechanical behavior of CEB reinforced with treated fibers was evaluated by measuring the flexural and compressive strengths.

2 Preparation of Materials

2.1 Algae Fibers

The algae fibers used in this study are generated from the industrial processing of the red algae “*Gelidium Sesquipedale*” for agar-agar production, was provided by SETEXAM Company localized in Kenitra City (Morocco) (Fig. 1). They are composed mainly of $17.4 \pm 5.1\%$ cellulose, $4.3 \pm 2.8\%$ hemicellulose, $17.0 \pm 4.7\%$ lignin and $31.9 \pm 0.5\%$ extractable elements [14]. The fibers are ground using a knife mill (lengths are between 1.5 mm and 15 mm).



Fig. 1. Algae fibers

2.2 Treatment of Algae Fibers

Algae fibers are treated to improve surface properties. Three types of treatment have been explored:

- **Pre-saturation:** The algae fibers were immersed in water for 15 min until pre-saturation
- **Alkaline treatment:** The algae fibers were immersed separately for 72 h in a solution of sodium bicarbonate (NaHCO_3) at 10% mass concentration. The treated fibers were washed several times with fresh water, until neutralization. Finally, the treated Alfa fibers were drained and dried in an oven at 60°C for 48 h.
- **Double coating treatment:** The algae fibers were immersed in linseed oil for 1 min, then the fibers were coated using metakaolin. The coated fibers are oven dried at

60 °C for 7 days. The methodology of this treatment is similar to the preparation of “Chicken fingers”.

The image of untreated and treated algae fibers are shown in Fig. 2. For untreated algae fibers, a smooth surface was observed, with absence of fiber fibrillation (Fig. 2-a). On the other hand, treated algae fibers with sodium bicarbonate show an increase in surface roughness and quality in terms of reduction of impurities (Fig. 2-b). The double coated fibers show that the surface of the fibers is well coated, and has a rough surface (Fig. 2-c).

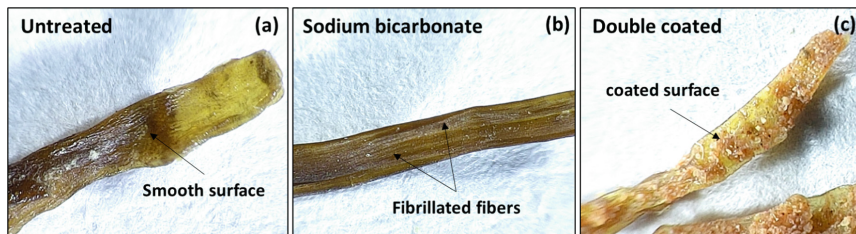


Fig. 2. Video microscope images of (a) Untreated algae fibers; (b) Sodium bicarbonate treatment; (c) Double coated treatment

3 Production and Characterization Methods of CEB

3.1 Composition of the Earth Mix

The earth mix used to manufacture the compacted earth blocks is based on a common formulation used by the company Briqueteries du Nord (Templeuve, France) for the manufacture of fired earth bricks by extrusion. This earth mix is composed of 60% Templeuve clay, 28% sand and 12% porphyry. The Templeuve clay is composed of a rather important quantity of fine particles, which represents approximately 95% of the total mass. The sand used has a particle size distribution of 0–1 mm and the porphyry has a particle size distribution of 0–2 mm. The addition of these two aggregates to complement the clay serves to both prevent cracking during the drying step, and adding porphyry reduce CEB drying time. The earth mix can be classified as a medium plasticity clay (Plasticity Index (PI) = 22%). The manufacturing water content of the CEB must be lower than the plasticity limit of the earth mix to ensure adaptation for shaping by compaction [15].

3.2 Hydraulic Press Used for CEB Manufacturing

The formulations are prepared by adding algae fibers to the earth mix for dry mixing for 1 min, then the water is added until the mixture is homogenized. After mixing, the moist material was statically compacted in a prismatic mould of dimensions $22 \times 11 \times 7.5$ cm and compacted with the Mecopress machine at pressure level of 12 MPa (Fig. 3).



Fig. 3. Mecopress machine and different steps in the manufacture of a block

After compaction, the blocks are manually taken carefully after demolding; they are then covered by a plastic film for 24 h so as to ensure its water content homogeneity, its sealing and avoid rapid drying. Then, the blocks are dried by exposure to air ($T = 20 \pm 2$ °C, Relative Humidity (RH) = $50 \pm 10\%$) until reaching constant mass (average 4 weeks). The different formulations are noted as follows: CEB_X stands for compacted earth brick reinforced with algae fibers, where X = addition ratio (%). In order to study the effect of fiber addition on the plasticity of the earth mix and to determine the water content suitable for compaction process, the Atterberg limits (EN ISO 17892-12) and the plunger penetration test (EN 1015-4) with a modification of the surcharge were carried out in the fresh state. The mechanical strengths of the CEB (compressive and flexural) were measured in the hardened state.

4 Results and Discussions

4.1 Fresh State Characterization: Atterberg Limits and Plunger Penetration with Surcharge

Table 1. Plasticity of the earth mix as a function of fiber content

| Fibers (%) | LL (%) | PL (%) | PI (%) |
|------------|--------------|--------------|--------------|
| 0 | 42.13 ± 0.41 | 20.65 ± 0.50 | 21.48 ± 0.09 |
| 0.5 | 43.39 ± 0.34 | 20.87 ± 0.37 | 22.52 ± 0.03 |
| 1 | 44.39 ± 0.38 | 21.52 ± 0.25 | 22.87 ± 0.13 |
| 1.5 | 45.76 ± 0.50 | 22.44 ± 0.45 | 23.32 ± 0.05 |
| 2 | 47.10 ± 0.45 | 23.02 ± 0.30 | 24.08 ± 0.15 |
| 3 | 49.03 ± 0.23 | 24.89 ± 0.46 | 24.14 ± 0.23 |

The effect of adding algae fibers with different content ratio on the plasticity of the earth mix are presented in Table 1. The increase in the addition rate of algae fibers does not affect the plasticity of the earth mix. The fiber mixtures represent a low plasticity that does not exceed a PI value of 24%. Figure 4 shows the influence of adding the algae fibers on the plunger penetration depth of the earth mix. The manufacturing water content of

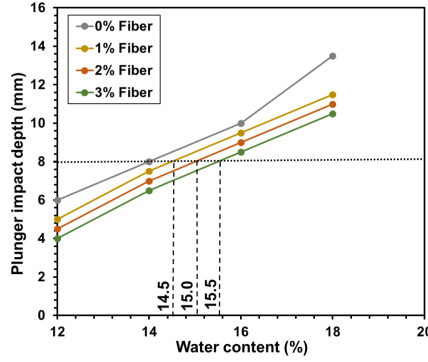


Fig. 4. Plunger impact depth as a function of water content

the CEB control is 14%, which corresponds to an overloaded plunger depth of 8 mm. The introduction of the algae fibers does not significantly affect the plunger penetration depth, which is in agreement with the plasticity results. Based on these results, a water correction to be made during fabrication was determined according to Eq. (1):

$$W_a(\%) = 0.5 \times \% F + W_i \quad (1)$$

W_a : Added water content; $\% F$: Fibers content; W_i : Initial water content, which is 14%.

4.2 Characterization of CEB in the Hardened State: Compressive and Flexural Strength

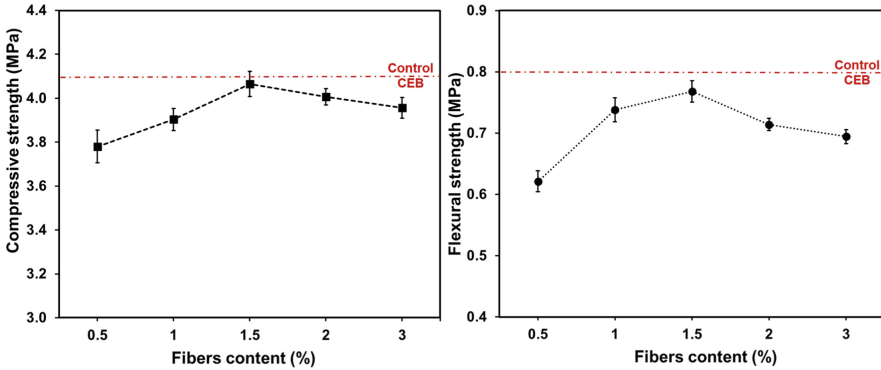


Fig. 5. Compressive and flexural strengths of unreinforced and algae fiber-reinforced CEB

Figure 5 shows the compressive and flexural strength as a function of algae fibers addition rate. The control CEB (CEB_0) has a compressive strength of 4.10 MPa and a flexural strength of 0.8 MPa. Compared to CEB_0 , the incorporation of algae fibers reduces the mechanical strengths. Indeed, $CEB_{0.5}$ has a compressive strength of 3.78 MPa, a

decrease of 7% compared to CEB₀. A decrease in flexural strength of 22% was also observed for this formulation. However, a slight decrease in mechanical strength was observed for CEB_{1.5}. Therefore, the addition ratio of 1.5% seems to be the best compared to the other addition content. This reduction in mechanical strengths could be related to the random distribution of fibers in the earth mix, which leads to the creation of voids inside the clay matrix. Similar results were observed by [6] with the addition of barley straw fibers. This behavior was attributed to the hydrophilic character of the fibers which enhances the porosity produced during the drying of the CEB. Based on the results obtained, it appears necessary to modify the surface of the algae fiber in order to decrease its water absorption capacity (hydrophilic properties) and improve its adhesive properties.

4.3 Effect of Fiber Treatments on the Mechanical Properties of CEB

According to the literature, the purpose of the treatments is to improve the adhesion properties of the fibers [16], which can strongly influence the fiber/matrix interface, and improve the mechanical properties of the composite. Alkaline treatment by sodium bicarbonate, double coating treatment by linseed oil and metakaolin, and pre-saturation of the fibers are carried out to improve the performance of the fiber within the clay matrix. CEB containing treated and untreated fibers are performed with a 1.5% mass fraction of algae fibers.

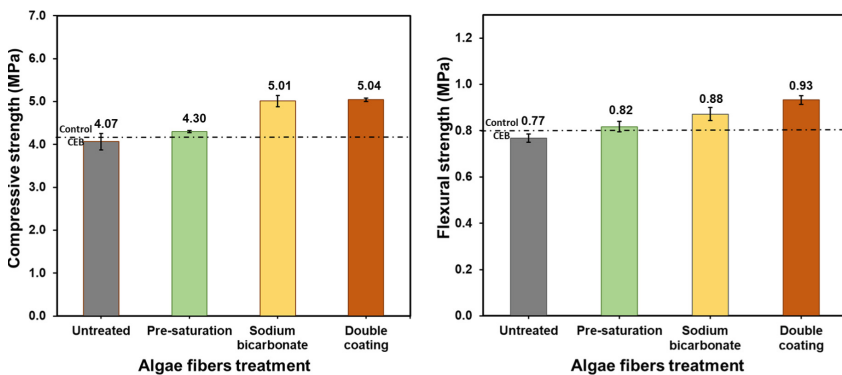


Fig. 6. Compressive and flexural strengths of CEB reinforced with treated algae fibers

Figure 6 shows the compressive and flexural strength of the CEB reinforced with the treated and untreated algae fibers. The incorporation of the raw algae fibers into the CEB leads to decrease the mechanical strengths compared to the control CEB. However, the treated algae fibers showed better behavior inside the matrix. An improvement in mechanical strengths was observed for all three treatments. A slight increase of 5.6% in compressive strength and 6.5% in flexural strength of the CEB containing pre-saturated fibers compared to the CEB with untreated fibers was observed. The CEB reinforced with the sodium bicarbonate treated fibers have a compressive strength of 5.01 MPa and a flexural strength of 0.88 MPa, an increase of 23% and 14% over the CEB reinforced with

the untreated fibers respectively. Similarly, the CEB containing the double coated algae fibers showed a 24% improvement in compressive strength and 20% enhancement in flexural strength. This proves the effectiveness of both treatments. Sodium bicarbonate treatment leads to the partial removal of some non-cellulosic compounds present in the fibers structure [17]. Therefore, the mechanical properties were improved due to the enhancement of fiber adhesion properties after treatment. The treatment by double coating allows to isolate the fibers from the matrix preventing its water absorption, in order to decrease their hydrophilic characters [9].



Fig. 7. Video microscope observation of the algae fiber and clay matrix interface: (a) untreated fiber; (b) pre-saturated fiber; (c) fiber treated by sodium bicarbonate, and (d) fiber treated by double coating

Figure 7 presents the fractured surface of CEB with untreated and treated algae fibers. The addition of algae fibers creates voids inside the matrix which leads to poor adhesion between the untreated algae fiber and the matrix (Fig. 7-a). The CEB reinforced with the treated algae fibers (Fig. 7-(b-d)) show a less porous aspect compared to the CEB containing the untreated fibers. In addition, the treated fibers show better adhesion with the clay matrix, which confirms the effectiveness of the treatment, and confirms the mechanical strength results.

5 Conclusion

The aim of this work is to study the influence of the addition of untreated and treated algae fibers on the mechanical properties of compacted earth bricks (CEB). The following main conclusions could be:

- The addition of the algal fibers did not affect the plasticity of the soil mixture, and did not significantly influence the manufacturing water content of the CEB.
- The incorporation of the algae fibers decreased the mechanical strengths. However, the addition of 1.5% seems to be the best compared to the other rates.
- The treated fibers showed a better adhesion with the clay matrix, this was confirmed by video microscope images. In addition, an increase in the mechanical strengths of the CEB reinforced with the treated algae fibers compared to the CEB reinforced with untreated fibers was observed.

From these results, it is possible to assert that treated algae fibers with sodium bicarbonate solution and double coating (linseed oil/metakaolin) leads to achieve highest interfacial adhesion with clay matrices thus leading to better mechanical properties of the CEB. The behavior of CEB containing treated fibers subjected to ageing tests will be studied to assess the durability performance of CEB. This study will present the objective of the following paper.

References

1. Pacheco-Torgal, F., Jalali, S.: Earth construction: lessons from the past for future eco-efficient construction. *Constr. Build. Mater.* **29**, 512–519 (2012)
2. Waziri, B.S., Lawan, Z.A., Mustapha, M.M.: Properties of compressed stabilized earth blocks (CSEB) for low-cost housing construction: a preliminary investigation. *Int. J. Sustain. Constr. Eng. Technol.* **4**(2), 39–46 (2013)
3. Meukam, P., Jannot, Y., Noumowe, A., Kofane, T.C.: Thermo physical characteristics of economical building materials. *Constr. Build. Mater.* **18**(6), 437–443 (2004)
4. Millogo, Y., Morel, J.C.: Microstructural characterization and mechanical properties of cement stabilised adobes. *Mater Struct.* **45**(9), 1311–1318 (2012)
5. Millogo, Y., Morel, J.C., Aubert, J.E., Ghavami, K.: Experimental analysis of pressed adobe blocks reinforced with hibiscus cannabinus fibers. *Constr. Build. Mater.* **52**, 71–78 (2014)
6. Laborel-Préneron, A., Aubert, J.E., Magniont, C., Maillard, P., Poirier, C.: Effect of plant aggregates on mechanical properties of earth bricks. *J. Mater. Civ. Eng.* **29**(12), 04017244 (2017)
7. Ajouguim, S., Talibi, S., Djelal-Dantec, C., Hajjou, H., Waqif, M., Stefanidou, M., et al.: Effect of Alfa fibers on the mechanical and thermal properties of compacted earth bricks. *Mater. Today: Proc.* **37**, 4049–4057 (2021)
8. Page, J., Khadraoui, F., Gomina, M., Boutouil, M.: Influence of different surface treatments on the water absorption capacity of flax fibres: rheology of fresh reinforced-mortars and mechanical properties in the hardened state. *Constr. Build. Mater.* **199**, 424–434 (2019)
9. Page, J., Amziane, S., Gomina, M., Djelal, C., Audonnet, F.: Using linseed oil as flax fibre coating for fibre-reinforced cementitious composite. *Ind. Crops Prod.* **161**, 113168 (2021)
10. Silva, E.J., Marques, M.L., Velasco, F.G., Junior, C.F., Luzardo, F.M., Tashima, M.M.: A new treatment for coconut fibers to improve the properties of cement-based composites—combined effect of natural latex/pozzolan materials. *Sustain. Mater. Technol.* **12**, 44–51 (2017)

11. Seo, Y.B., Lee, Y.W., Lee, C.H., You, H.C.: Red algae and their use in papermaking. *Biores. Technol.* **101**(7), 2549–2553 (2010)
12. Ouhssine, K., Ouhssine, M., Elyachoui, M. : L'application des déchets traités de l'algue *Gelidium sesquipedale* dans la culture du Maïs. *Afrique Sci.: Rev. Int. Sci. Technol.* **3**(2) (2007)
13. El Achaby, M., Kassab, Z., Aboulkas, A., Gaillard, C., Barakat, A.: Reuse of red algae waste for the production of cellulose nanocrystals and its application in polymer nanocomposites. *Int. J. Biol. Macromol.* **106**, 681–691 (2018)
14. Tayibi, S., et al.: One-pot activation and pyrolysis of Moroccan *Gelidium sesquipedale* red macroalgae residue: production of an efficient adsorbent biochar. *Biochar.* **1**(4), 401–412 (2019)
15. Talibi, S., Page, J., Djelal, C., Waqif, M., Saâdi, L.: Study of earth-based materials for manufacturing compaction process. *J. Build. Eng.* **64**, 105546 (2023)
16. Ajouguim, S., Page, J., Djelal, C., Waqif, M., Saadi, L.: Performance of Alfa fibres in cementitious materials exposed to diverse surface treatments. *Constr. Technol. Archit.* **1**, 660–667 (2022)
17. Fiore, V., Scalici, T., Nicoletti, F., Vitale, G., Prestipino, M., Valenza, A.: A new eco-friendly chemical treatment of natural fibres: effect of sodium bicarbonate on properties of sisal fibre and its epoxy composites. *Compos. B Eng.* **85**, 150–160 (2016)

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