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João Batista de Oliveira Libório Dourado[a], Maria Elayne Rodrigues Alves[b], Wilson Alves de Oliveira Júnior[b], Bruna Leal Melo de Oliveira[c], Hitalo de Jesus Bezerra da Silva[d], Alberto López-Galindo[e], César Viseras[e], Marcelo Barbosa Furtini[f], and Valdeci Bosco dos Santos[b]

[a]Graduate Program in Materials Science and Engineering, Technology Center, Federal University of Piauí, Teresina, Brazil; [b]Department of Materials Engineering, Technology Center, Federal University of Piauí, Teresina, Brazil; [c]Department of Water Resources, Geotechnics and Environmental Sanitation, Technology Center, Federal University of Piauí, Teresina, Brazil; [d]Graduate Program in Materials Science, Federal University of Pernambuco, Recife, Pernambuco, Brazil; [e]Instituto Andaluz de Ciencias de la Tierra (Consejo Superior de Investigaciones Científicas-University of Granada), Armilla, Granada, Spain; [f]Department of Civil Construction and Architecture, Technology Center, Federal University of Piauí, Teresina, Brazil

ABSTRACT

Babassu carbohydrate fibers (BCF) are abundant and renewable materials that are currently underutilized. The present work evaluates the use of alkaline-treated BCF (TF – 0.6, 1.0, 1.4% w/w) as additive to cementitious mortars. Mass consistency, specific mass, water absorption, void ratio, and porosity, as well as compressive and indirect tension fracture strengths, were evaluated and compared to control mortars (without fiber addition). The results confirmed that the treated BCF can be an effective alternative as a potential reinforcement in cementitious composites. Furthermore, they are prepared by an alkaline treatment that is easy to operate, cost-effective, and efficient. The addition of BCF to the cement matrix decreased the water absorption capacity and void ratio, whereas increased compressive and tensile strength compared to mortars prepared in the absence of BCF. In particular, the addition of 1.0% of TF increased the compressive strength by up to 77%. Good interfacial adhesion of the alkaline-treated BCF with the rest of mortar components resulted in an increase in the values of mechanical properties. The studied fibers are potential materials for new sustainable mortars with improved properties.

摘要

巴巴苏碳水化合物纤维（BCF）是丰富的可再生材料，至今未得到充分利用. 本工作评估了碱处理BCF（TF-0.6,1.0,1.4%w/w）作为水泥砂浆添加剂的使用. 对质量稠度、比质量、吸水率、孔隙比和孔隙率以及抗压和间接拉伸断裂强度进行了评估，并与对照砂浆（不添加纤维）进行了比较. 结果证实，经处理的BCF可以作为水泥基复合材料中潜在的补强材料的有效替代品. 此外，它们是通过易于操作、经济高效的碱性处理制备的. 与不含BCF的砂浆相比，在水泥基体中添加BCF降低了吸水能力和空隙率，而提高了抗压和抗拉强度. 特别是，添加1.0%的TF可使抗压强度提高77%. 碱性处理的BCF与其余砂浆组分的良好界面粘附性导致机械性能值的增加. 所研究的纤维是具有改进性能的新型可持续砂浆的潜在材料.

KEYWORDS

Babassu epicarp fibers; alkaline treatment; cementitious mortars; physical properties; mechanical properties; fiber-cement matrix interaction

关键词

巴巴苏外果皮纤维; 碱处理; 水泥砂浆; 物理性质; 机械性能; 纤维-水泥基体相互作用

CONTACT Alberto López-Galindo alberto@iact.ugr-csic.es Instituto Andaluz de Ciencias de la Tierra (Consejo Superior de Investigaciones Científicas-University of Granada), Armilla, Granada, Spain

Introduction

Natural fibers exhibit advantageous features to replace synthetic fibers; they are abundant, renewable, biodegradable, nontoxic, light, and low cost (Mehrez et al. 2023). In particular, Babassu carbohydrate fibers (BCF) have been used in polymeric films (Raposo et al. 2021), temperature, or mechanical resistant materials (Furtado et al. 2020). Babassu (*Orbignya speciosa*) is a palm tree native to Brazil, with abundant occurrence in the Northeast and North regions (Carrazza, Carlos Cruz Ávila, and Lima Silva 2012). Maranhão and Piauí states have 14 million hectares of babassu plants (CONAB Companhia Nacional de Abastecimento 2021), producing several tons of bear fruit per hectare per year and playing an important socio-economic role for the 300.000 women working as "nut breakers" in rural populations. Despite the multifunctionality of the babassu nut, most industries are primarily interested in the oil extracted from the babassu nut. The sale of almonds provides a small income for families, often serving as their sole or main source of income (Saraiva et al. 2022). In addition to the almond, the babassu coconut consists of three other parts (mesocarp, endocarp, and epicarp), which are by-products of oil extraction. Each ton of babassu nut generates 930 kg of these residues (Protásio et al. 2014). Therefore, the babassu epicarp fibers, which are currently undervalued, present an opportunity for extraction and commercialization in construction industry. This would provide an additional income source for families, encourage and improve practices to add value, and open up markets for babassu by-products. Furthermore, it could lead to the establishment of more associations and cooperatives for babassu nut breaking and collection. These cooperative ventures function as solidarity-based enterprises that aim to alleviate the social and economic difficulties faced by their members. In addition to the biodegradable nature of babassu fibers, their acquisition cost is low compared to synthetic fibers. Furthermore, the use of these fibers can contribute to the economic growth of the regions where babassu is prevalent, thereby strengthening family farming. It is worth emphasizing the importance of this productive chain in ensuring the continuity and preservation of the culture of these families in the region. The babassu epicarp is the outermost layer (shell) of the fruit formed by mechanically resistant fibers, corresponding to 12% of the total weight of the fruit. Most of this lignocellulosic residue is underutilized and accumulates in fruit processing sites and/or in the backyard of homes (Cabral et al. 2012), which may cause damage to human and domestic animal health, to the soil and water table, as well as to adjacent vegetation (Lemos and Carneiro Souza 2018).

There is an urgency to make buildings more ecoefficient and reduce the impact of cities on climate change and global warming, including the development of local-based construction material (Huang and Rodrigue 2022). In recent years, different strategies have proved additives to improve construction material, including rice husk, cane bagasse, corn cob (Amantino et al. 2022; Ardanuy, Claramunt, and Dias Toledo Filho 2015; Potiron et al. 2022) as well as natural fibers such as coir (Ayeni et al. 2022; Islam and Ju Ahmed 2018) and jute (Andiç-Çakir et al. 2014; Fonseca et al. 2019). In particular, the addition of fibers increased the compressive strength, tensile and flexure strength, toughness, and crack strength of cementitious materials (Andiç-Çakir et al. 2014; Islam and Ju Ahmed 2018). Natural fibers may require treatments before their use, as they are composed of variable proportions of cellulose together with amorphous components (hemicellulose, lignin, and waxes) resulting in high moisture absorption that may be incompatible with the cementitious matrix (Onuaguluchi and Banthia 2016). This may be resolved by different chemical treatments (alkali, acetylation, silane, and peroxide) (Kabir et al. 2012; Khalid et al. 2021). In particular, alkaline treatment with NaOH is a frequent treatment, breaking down the hydrogen bonding in fiber surfaces and removing the impurities. This treatment reduces moisture absorption and amorphous components as well as promotes fiber surface rougher, improving fiber adhesion to the matrix cement (Balaji and Nagarajan 2017), directly influencing in the improve compression tension and deformation of the resultant composites.

With these premises, the aim of this study was to investigate the use of alkali-treated BCF, to prepare cementitious mortars with improved mechanical properties.

Materials and methods

Materials

BCF extracted from the shell from Babassu nuts (Figure 1) of Fazenda da Paz Women's Therapeutic Community (Teresina, Piauí, Brazil) was supplied by Babcoall Inc. do Brasil, LTDA. A hammer mill (15 HP electric motor) was used for simple defibrillation by impact stress that could easily be used in large quantities. NaOH (P.A, VETEC), Portland cement (CPII-E 32, fineness modulus of 3.6 and a specific gravity of 3.02 g/cm^3) and natural river sand (fineness modulus of 1.61 and density of 2.62 g/cm^3, dried at 110°C/24 h to eliminate hydration water) were also used.

Chemical treatment and characterization of babassu nut fibers

BCF were separated from small components by sieving (mesh #16; 1.19 mm). The positive fraction was collected, washed under running water to remove impurities (traces of mesocarp, waxes, and others) and final wash in distilled water. Then, BCF were dried at 60°C/24 h (the resultant material was named NF). A fraction was treated with a NaOH solution (5% by weight) for 3 h, washed repeatedly in distilled water until it reached neutralization (pH = 7), and dried (60°C/24 h) (Balaji and Nagarajan 2017; Oushabi et al. 2017), being called TF (BCF alkaline treated).

The crystal structure of the NF and TF was characterized by X-ray diffraction (XRD, Shimadzu XRD-6000 diffractometer). The crystallinity index (CI) of the fibers was calculated by Equation 1.

$$CI(\%) = [(I_{002} - I_{am})/I_{002}]x100 \tag{1}$$

Where I_{002} is the maximum peak intensity (crystalline phase, 2θ ≅ 22°), and I_{am} is the minimum intensity (2θ ≅ 18°) of amorphous fraction between the (101) and (002) peaks. The length and diameters of 50 units of NF and TF were measured by a digital caliper (±0.1 mm) and a micrometer (±0.01 mm), respectively. The aspect ratio (L/D, ratio between average length and average diameter) of the fibers was calculated. The determination of the specific mass of the fibers was obtained by the pycnometer method (Brasileiro, Augusto Rocha Vieira, and Silva Barreto 2013). Water absorption was determined by immersion (Sawsen et al. 2015). The specific mass and water absorption tests were

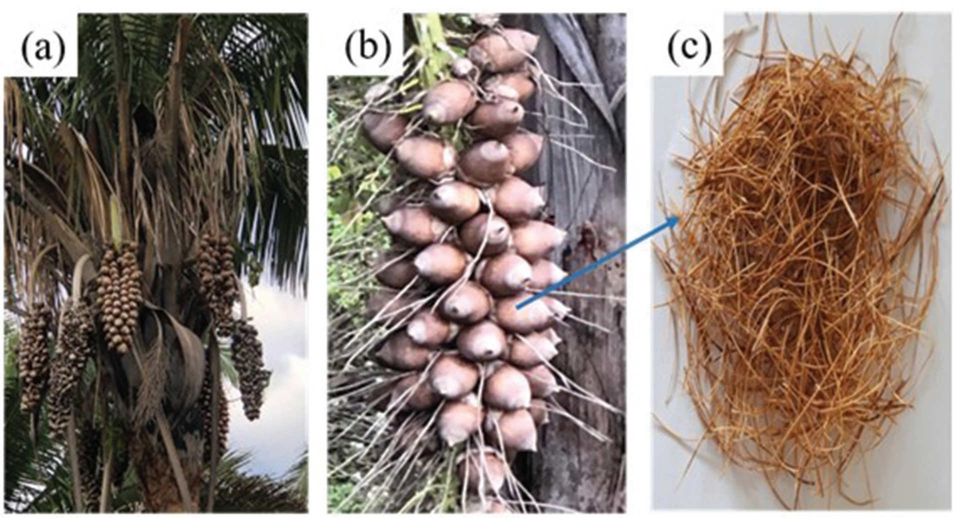

Figure 1. Photo of (a) Babassu Palm, (b) close-up of the babassu coconut (c) fibers of the babassu coconut shell.

performed in triplicate. Tensile strengths were determined using a Universal Testing Machine (Instron, Emic model, PC200C), using a 5kN load cell, working at 0.005 mm/min. Ten NF and TF samples were tested (ASTM C1557 2014).

Preparation and characterization of reinforced mortars

The reinforced mortars (RM) were prepared with the addition of 0.6%, 1.0%, and 1.4% (m/m) of TF, obtaining samples RM06, RM10, and RM14, respectively. The chosen BCF percentages (0.6, 1.0, 1.4%) were based on previous studies with other natural fibers. Dawood and Ramli (2012) used natural fibers in proportions ranging from 0.2% to 1.6% to the total cement volume. Çomak, Bideci, and Salli Bideci (2018) also used low proportions of natural fibers relative to the cement, ranging from 1%, 2%, to 3%, and obtained favorable results in their samples for compression and tension. Eires, Cardoso, and Camões (2014), despite not using cement, conducted tests by mixing lime, sand, and soil with fibers of sisal, banana, coir, and polypropylene in a proportion of 0.24 relative to the mass of the dry mixture. If we convert our research to a proportion of the mixture's mass, we can observe that 0.6% to 1.4% relative to the cement would be approximately 0.15% to 0.35% relative to the dry mixture, which aligns with Eires' findings. In conclusion, the choice of 0.6%, 1%, and 1.4% for the cement fibers was selected to find a plateau of maximum resistance and possibly a reduction in strength if the fiber content was decreased or increased. For comparison, control mortars (CM, without the addition of fibers) were also prepared. For all mortars, the same water/cement ratio of 0.71 and cement/sand of 1:3 (by mass) were maintained. The mortars were formulated according to ABNT NBR 7215 (2019) and using cylinders of 50 × 100 mm. After 24 h, all samples were de-molded and cured in water for 28 days.

For the mortar in the fresh state, the determination of consistency by spreading of the cone trunk on the table was performed according to ABNT NBR 13276 (1988). After 28 days of cure, the physical properties of the mortar samples in the hardened state were determined by the specific mass, water absorption, and void ratio tests, according to the same ABNT NBR 9778 (2005). Initially, the samples dried at 100°C/24 h were weighed. Then, they were submerged in water for 24 h and after their removal, their surfaces were dried and the immersed mass was weighed. Saturated mass was measured after 24-h immersion in water by using a hydrostatic balance. For each formulation of mortar, four units of specimens were characterized.

Axial compression and splitting tensile tests were carried out according to ABNT NBR 7215 (2019and ABNT NBR 7222 (2011), respectively, using Universal Testing Machine (Instron, Emic model, PC200C). A 2000 kN load cell, at a loading speed of 0.25 MPa/second, was used for both tests. For each strength test, four cylindrical specimens were used, and the average strength was determined. The crack patterns after compressive and splitting tensile studies were also evaluated. The morphological surface of the NF and TF, as well as the fiber (NF and TF) interfacial connection and cement matrix were evaluated using an SEM (Quanta FEG 250, FEI), silver cover.

Results and discussion

X-ray diffractograms of the BCF (Figure 2) showed three main crystallographic peaks, corresponding approximately to 2θ equal to 16° (101), 22° (002), and 35° (040). The broader reflections (101) and (040) correspond to cellulosic amorphous regions (hemicellulose and lignin). The most intense crystallographic plane (002) corresponds to crystalline phase of cellulose type I (native cellulose) (Balaji and Nagarajan 2017).

TF presented a CI equal to 49.76%, higher than the NF (44.98%). Comparing their values, it was observed that the increase of this index in the TF can be attributed to a partial removal of the amorphous constituents (hemicellulose and lignin) and to the packing of the crystalline domains, which leads to a higher proportion of cellulose (degree of crystallinity) (Moshi et al. 2020). These results suggest that the treatment with NaOH (5% by weight) was effective in removing the non-

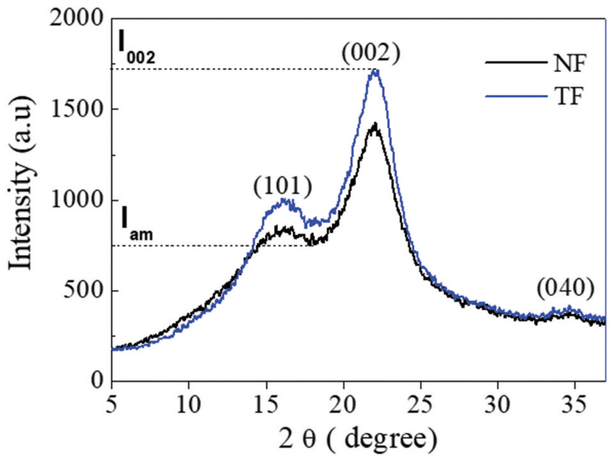

Figure 2. X-ray diffractogram of the NF and TF samples.

crystalline fraction of the fibers, suggesting that when chemically treated, they can offer advantages to the processing and properties of composite materials (Oushabi et al. 2017).

Figure 3 shows the morphological changes of the longitudinal surfaces of babassu nut fibers before and after chemical treatment. NF (Figure 3a) showed an irregular surface, associated with the presence of impurities (waxes, oils, hemicellulose, lignin, and others), which are often found in the surface layer of most natural fibers (Moshi et al. 2020) and that usually reduce the adhesion between fiber and matrix. For TF (Figure 3b), it was observed rough surface regions with more exposed globular marks, which may infer that the alkaline treatment promoted the partial removal of hemicellulose and lignin, as well as the dissolution of the other amorphous non-cellulosic components.

Therefore, chemical treatment cleaned the fiber surfaces, a requisite for adequate adherence of the fibers with the other mortar components and the resulting mechanical performance. Similar results were also observed by Onuaguluchi and Banthia (2016) and Oushabi et al. (2017), with coir, sisal, pineapple, and palm fibers chemically treated. Reduction of amorphous components (hemicellulose, lignin, and waxes) in natural fiber induces changes in their physical and mechanical properties (Kabir et al. 2012). In our study, it was observed a reduction in the average length and diameter of the fibers and thus promoted an increase of 12% in the aspect ratio (L/D) of TF compared to NF, with a reduction in specific mass of approximately 6% (Table 1). The aspect ratio tends to positively influence the fiber and cement matrix interface, and consequently the mechanical properties of its composites (Meza and Siddique 2019). It can also be verified that after 24 h, the TF showed a reduction of 7% in the water absorption capacity compared to the NF. Therefore, the hydrophilic nature of the fibers was reduced, since the partial removal of hemicellulose (the main affinity component of hydroxyl groups in natural fibers) occurred (Saghrouni, Baillis, and Jemni 2020). This low water absorption capacity can have a positive effect on the processing of fresh mixtures, on the hydration of the cement during the curing stage, as well as providing a good adhesion between the TF and the cementitious matrix (Kabir et al. 2012; Martel, Salgado, and Silva 2022).

The result of tensile strength of the TF showed an improvement of 16.33%, in relation to the NF. This may be a reflection of a higher proportion of TF cellulose, as indicated by the CI value obtained by XRD Cellulose is responsible for offering mechanical resistance to natural fibers, and its content positively influences the mechanical properties of a fiber-reinforced composite material (Balaji and Nagarajan 2017). The tensile strength of the TF is comparable to that of other fibers (flax, palm, and kenaf) chemically treated with NaOH (Sawsen et al. 2014; Yan, Kasal, and Huang 2016). Therefore, TF showed reduced length, diameter, water absorption, and density, as well as increased tensile strength

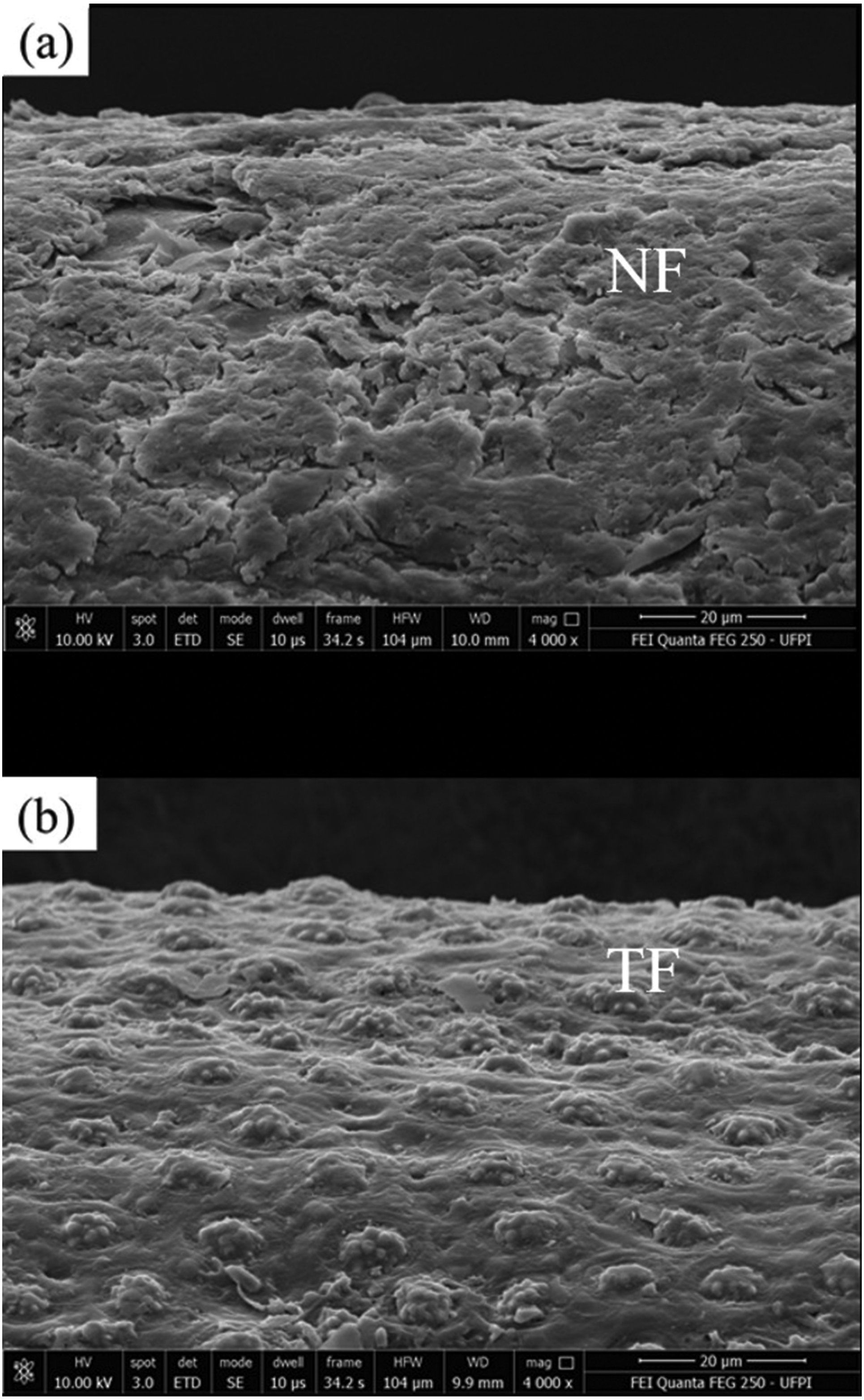

Figure 3. SEM (magnification of 4000×) of longitudinal surfaces: (a) NF e (b) TF.

Table 1. Average values of babassu coconut fiber properties.

Sample	Length (L) (mm)	Diameter (D) (mm)	L/D	Specific mass (g/cm^3)	Water absorption (%), 24 h	Tensile strength (MPa)
NF	34.20 ± 11.83	0.53 ± 0.11	62.86 ± 10.30	1.67 ± 0.11	38.24 ± 0.68	215.44 ± 63.69
TF	30.70 ± 6.60	0.44 ± 0.09	70.52 ± 3.66	1.57 ± 0.07	35.49 ± 0.20	250.63 ± 40.94

Note: ± The data represent the mean and standard deviation.

compared to NF. All these characteristics of BCF were improved by the alkaline treatment with NaOH (5% by weight) and corroborate the results of XRD and SEM.

The incorporation of high proportions of fibers can remarkably reduce the workability of fresh cementitious composites (Sadrinejad, Madandoust, and Mohammad Ranjbar 2018) which is detrimental to the other properties of these composites in a hardened state. To evaluate this effect, the consistency of CM was compared to the resultant RM consistencies. In the fresh state, the CM sample showed a consistency of 25.0 cm. The addition of TF in mortars did not change the consistency values. For the RM06, RM10, and RM14 samples, the mass consistency indexes were 24.7, 25.4, and 24.8 cm, respectively. These minor and negligible differences are explained as a result of the low content and low hydrophilic character of the treated fibers, in agreement with Cao, Ling, and Zhang (2018).

Inclusion of fibers may contribute to reduction of the apparent specific mass of mortars, due to the greater generation of porosity (Vantadori, Carpinteri, and Zanichelli 2019). In our case, the small amounts of added fibers did not have significant effects on the specific mass values. Table 2 shows the results of the physical and mechanical properties of mortars after 28 days. All reinforced mortars showed compressive strength values higher than CM. Compressive strength of reinforced mortars increases by up to 75% in RM06 and RM10 to decrease in RM14 (49%). A similar reduction in compressive strength with the incorporation of higher fiber contents was observed by Donnini, Bellezze, and Corinaldesi (2018). These results are in good agreement with those obtained for the water absorption and void ratios.

The addition of fibers promoted, in general, a decrease in water absorption and porosity of mortars, in accordance with previous studies (Jaber 2016; Lertwattanaruk and Suntijitto 2015). Low amounts of fibers improve adhesion to cement, forming a network in the mortar structure, which decreases permeability and increases mass compaction, whereas high fiber contents may result in poor dispersion and increase the volume of voids inside the cementitious composite (Al-Ghaban, Jaber, and Shaher 2018; Jaber 2016). In concordance with these studies, void ratios and water absorption of the studied mortars decreased in RM06 and RM10 to increase again in sample RM14.

In the studied samples, a good linear correlation between voids ratios and water absorption was found (Figure 4). It is well known that the presence of voids in mortar structure greatly affect water absorption (Hall 1989). Voids provide water storage at a much higher concentration than in the matrix, acting as a sink. In polymeric matrices, the system behavior is explained by the increase in water in the voids up to their saturation (wet equilibrium state) (Xinxin et al. 2018). As has been described with cement mortars incorporating fiber, water absorption supplies useful information about the permeable pore volume and potential connectivity between pores (Gil, Bernat-Masó, and Javier Cañavate 2016). In the studied mortars, a preponderant influence of the filling of voids is

Table 2. Physical and mechanical properties of the studied mortars.

Sample	Specific mass (g/cm^3)	Void ratio (%)	Porosity (%)	Water absorption (%)	Compression strength (MPa)	Splitting tensile (MPa)
CM	2.52 ± 0.03	22.76 ± 0.89	18.54 ± 0.59	11.69 ± 0.46	9.80 ± 0.27	1.83 ± 0.08
RM06	2.52 ± 0.13	21.36 ± 1.19	17.59 ± 0.65	10.79 ± 0.20	17.22 ± 1.24	2.18 ± 0.11
RM10	2.47 ± 0.07	20.66 ± 0.53	17.12 ± 0.37	10.53 ± 0.05	17.36 ± 0.65	2.14 ± 0.11
RM14	2.51 ± 0.06	21.71 ± 0.59	17.83 ± 0.40	11.04 ± 0.19	14.59 ± 1.15	1.96 ± 0.35

Note: ± The data represent the mean and standard deviation.

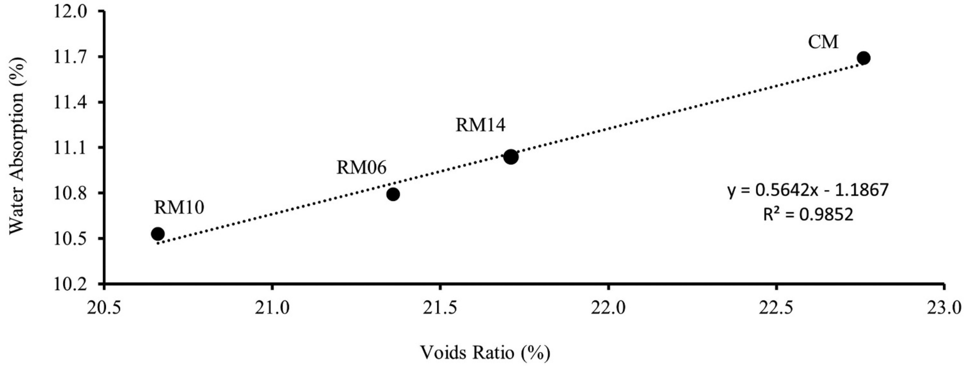

Figure 4. Relation between the void ratio and water absorption of the studied mortars.

assumed, and the global diffusion kinetics are supposed to be independent of the hydrostatic pressure. Accordingly, the constant ratio in Figure 4 will allow prediction of water absorption of reinforced mortars with different fiber percentages.

Compressive strength has been correlated to porosity in concrete (Page et al. 2017) and mortar (Chen, Shengxing, and Zhou 2013). In our study, the increase in porosity of mortars depresses their compressive strength. The correlation was fitted with linear or exponential equations (Figure 5) as those proposed by Hasselman (1969) and Ryshkewitch (1953) for refractory or inorganic oxide-based materials. The development of the mechanical strength properties of fiber-reinforced cementitious composites is directly related to the characteristics of the fiber type (chemical composition, crystallinity, shape, dimensions, specific mass and mechanical strength) (Kumar and Roy 2018). In this context, the high values of compressive strength observed for the studied mortars can be attributed to the improvement of their characteristics (chemical/physical/mechanical), as previously discussed. In addition, factors such as the proportion of fibers and their interaction with the cementitious matrix (SEM results discussed later), were determinant for the strength behavior of the composite (Ardanuy, Claramunt, and Dias Toledo Filho 2015).

For tensile splitting (Table 2), the addition of fibers increases the values compared to CM. The increase achieves a maximum at RM06 (~20%) to became almost negligible in sample RM14. Even if

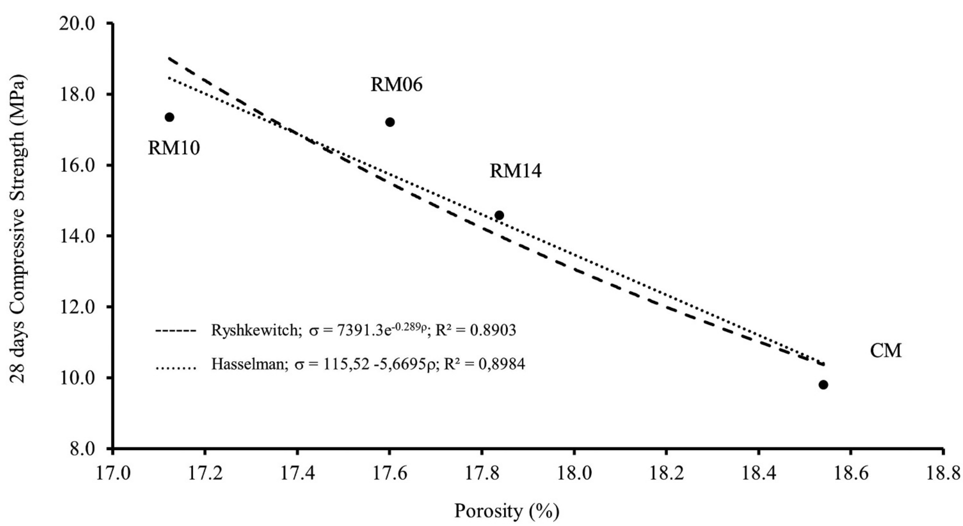

Figure 5. Compressive strength (σ) as a function of the mortar porosity (ρ).

these values showed high variability, it is clear again that the addition of high concentrations of TF may cause a reduction in the mechanical properties of reinforced mortars. Islam and Ju Ahmed (2018) and Kumar and Roy (2018) also observed a similar trend toward higher levels of fibers incorporated into mortars. The reasons for the indirect tensile behavior of these TF reinforced mortars are identical to those explained in the discussion of the compression behavior, even if for splitting results variability difficult the clear explanation of the behavior.

Failure patterns, after compressive (Figure 6) and splitting tensile test (Figure 7) were also evaluated. As observed, the TF acted as an effective reinforcement in restricting the development of a sudden break in cementitious mortars. For the CM sample (Figure 6a), after reaching its tension limit, basically a large and single fracture pattern can be seen, which tends to increase until complete rupture. Crack patterns of all reinforced mortars (Figure 6b–d) showed irregularly and randomly propagated cracks throughout the entire sample. These cracks were probably maintained by the good TF interfacial bond and cementitious matrix, due to a transfer of tension to the fiber and good load redistribution in the cementitious matrix (Sawsen et al. 2014).

Therefore, through the effect of TF on the crack strength of mortars, it can be concluded that they are effectively able to avoid and restrict the early tendency of mortar separation. This results in a greater capacity to withstand significantly the applied stress, and consequently, they presented an increase in compressive strength in all reinforced mortars. Clearly, the TF operated

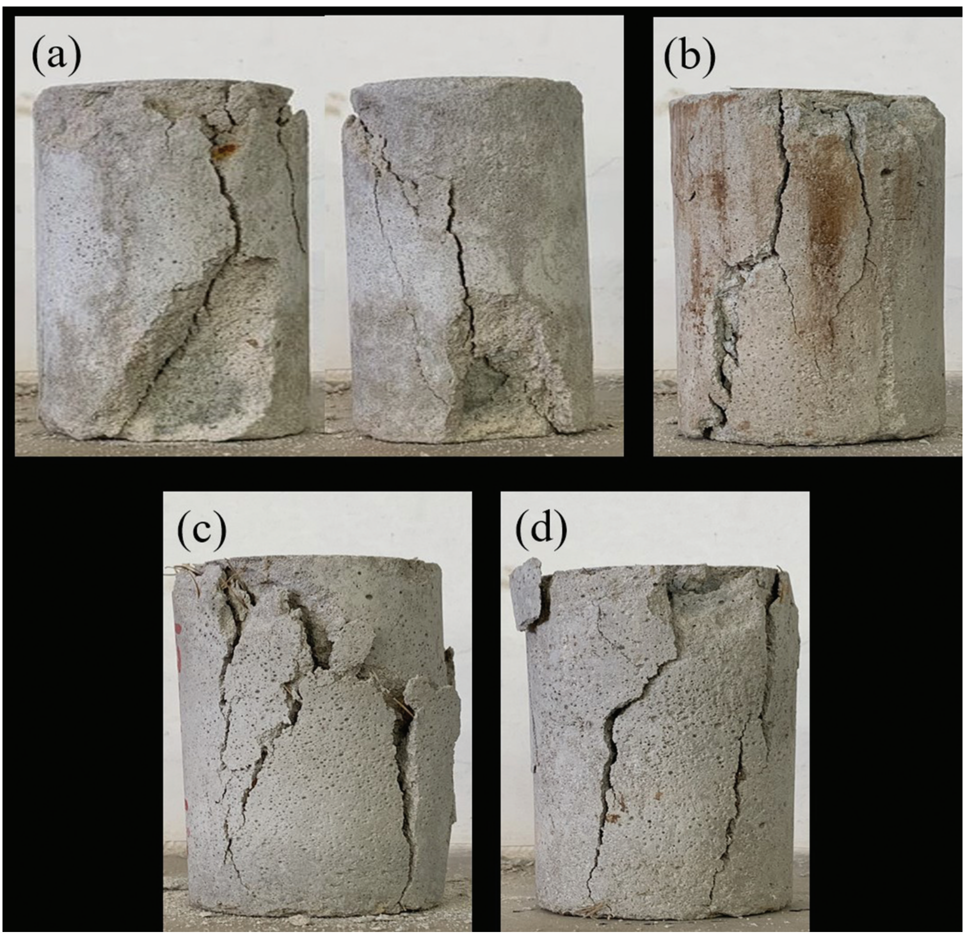

Figure 6. Mortar failure patterns, under compression test: (a) CM, (b) RM06, (c) RM10 and (d) RM14.

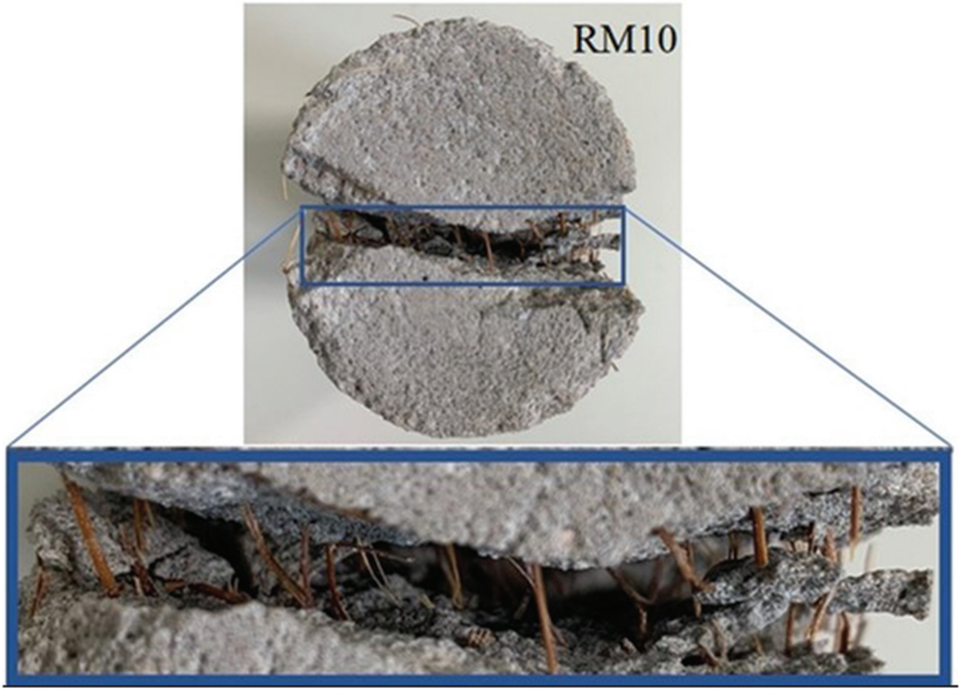

Figure 7. Failure pattern of reinforced mortars under splitting tensile test with detail of the cross-section of the fractured specimen and fiber bridge effect.

as a bridge in the transfer of tensile loads (Yan, Kasal, and Huang 2016) even once achieved the fracture, as observed in Figure 7. The two sides of the mortars are interconnected by the treated fibers. This failure pattern was observed for all reinforced mortar formulations.

The interfacial contact between the (treated and untreated) BCF and the cementitious mortar, after the cure of the cement, is observed in Figure 8. For mortar with NF (Figure 8a), considerable voids can be seen between the fiber and the cementitious matrix, suggesting poor interfacial adhesion. This may be due to the presence of the impurities (waxes, oils, hemicellulose, and lignin) on the NF surface (as shown in Figure 3a), as well as the incompatibility between these fibers which are hydrophilic and mortar. Therefore, probably, the presence of NF in the mortar can contribute little to the mechanical strength and/or a minimum load can be enough to pull out the NF from cementitious mortar. The SEM images (Figure 8b, c) showed that the TF is well adhered to the mortar, with no visual differentiation (Figure 8c) between them. This was attributed to the NaOH treatment caused by dissolution of surface impurities of the fiber, promoting less hydrophilic character, higher aspect ratio, and roughness (as shown in Figure 3b and Table 1), thus contributing to better mechanical interlocking between fiber and cementitious matrix. These factors allowed a good TF-cementitious bond, and thus higher values of mechanical properties discussed previously. The enlarged region (Figure 8d), corresponding to the surface of the TF homogeneously covered by cement particles, reaffirms not only a better interfacial interaction TF-cement matrix but also the existence of a cement crystallization process (Saghrouni, Baillis, and Jemni 2020).

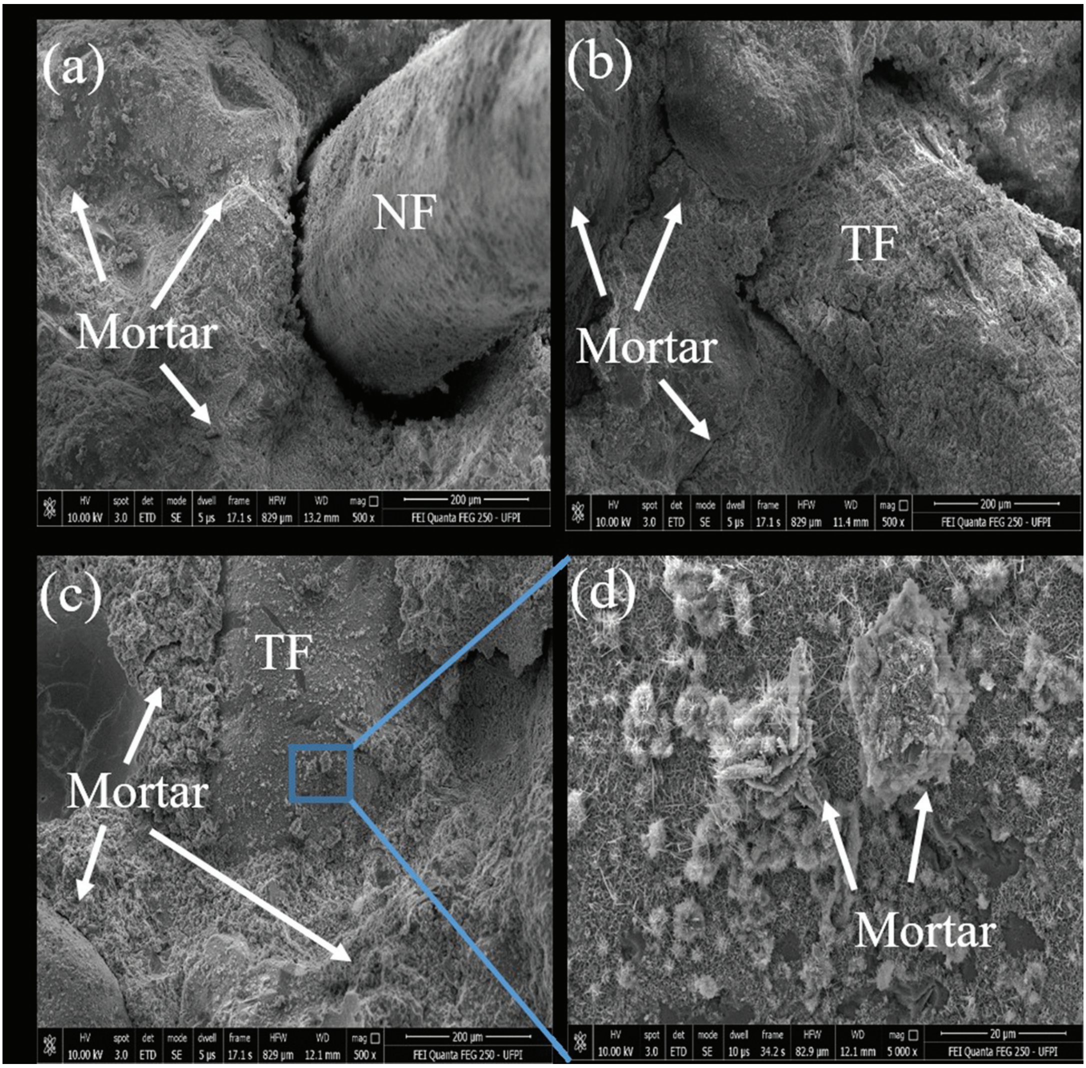

Figure 8. SEM images of babassu coconut epicarp fibers reinforced mortars: (a) NF (500×), (b) - (c) TF (500×), (d) TF (5000×, fiber surface covered by mortar).

Conclusions

Treatment with NaOH improved the physical and mechanical properties of BCF by decreasing amorphous components. The addition of TF to mortars did not modify their consistency (fresh) nor their specific masses (hardener). On the other hand, the addition of TF to mortars reduced their water absorption capacity and void ratios. As a result of the inclusion of TF, a substantial increase in compressive strength of reinforced mortars was observed. The increase in mechanical resistance was correlated to the resultant porosity and could be fitted by classical equations. An increase in the indirect tensile strength was also observed and related to the prevention of early fracture of mortars. It was observed the presence of fibers acting as bridges in the cracks and inducing the transfer of loads both in compression and indirect tensile test cracks. Therefore, the use of treated BCF in the cementitious matrices improved their mechanical properties being a sustainable additive for the construction industry.

The addition of 1.0% TF significantly improved the enhanced compressive and indirect tensile strength, and lower water absorption and porosity compared to mortars without TF. Hence, RM10 containing 1.0% TF can be considered an optimal concentration.

Highlights

- TF (alkaline treated Babassu carbohydrate fibers – BCF) were characterized.
- TF improved the physical properties of cementitious mortars.
- TF contributed up to 77% to the compressive strength of mortars.
- TF were effective in controlling the spread of cracks in the mortar.
- TF – cementitious mortars may be new components for the construction industry.

Abbreviations

BCF Babassu carbohydrate fibers
CI Cristallinity Index
CM Control mortars
NF BCF Not treated
RM Reinforced mortars
TF BCF alkaline treated

Disclosure statement

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