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Evaluation of the Technological Properties of Soil–Cement Bricks with Incorporation of Coconut Fiber Powder

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Abstract: The objective of this work was to evaluate the effect of partial replacement of soil by different percentages of coconut fiber powder in the manufacture of soil–cement bricks. The reference mix ratio of 10:1 (soil:cement) in volume was used for the manufacture of bricks, in addition to the partial replacement of soil mass by 5, 10, and 15% of coconut fiber. The characterization of the raw materials was performed with the analysis of the granulometry, together with technological tests, such as mechanical compressive strength and water absorption. As a result, it was observed that the soil has 34.30% clay and 62.80% sand, characterizing a sandy-clay soil type and the coconut fiber powder was characterized as a fine aggregate. The mechanical compressive strength tests showed a decrease in their average values according to the increase in the incorporation of coconut fiber into the bricks. It was concluded that the results of the mechanical compressive strength and some of the water absorption are in disagreement with the Brazilian technical standard. This conclusion corroborates other studies that show the difficulty in standardizing reference mixtures and working with soil, which is a highly heterogeneous material.

Keywords: coconut fiber; agricultural waste; soil–cement bricks; compressive strength

1. Introduction

The increase in solid waste generated worldwide is linked to the process of urbanization and the population's consumption rate, which, besides demanding greater consumption of natural resources, can impact the accumulation of solid waste and consequently overload the management of this waste [1]. A study conducted by [2] showed that the generation of municipal solid waste on a global scale in the year 2016 reached 2.01 billion tons, and that the management of at least 663.3 million brings great insecurity in environmental terms, besides predicting a 69.15% increase in the amount of waste generated by 2050. Despite having waste processing resources and adequate infrastructure, developed countries misuse them, while underdeveloped and developing countries suffer from the shortage of these same resources [3].

Currently, in many countries, agricultural waste is becoming an environmental problem due to its improper disposal [4]. Coconut is an agricultural waste often found in places with tropical climates such as Brazil, and the waste from its processing, when discarded or burned, can create problems for the environment [5]. According to the statistical base of the Food and Agriculture Organization of the United Nations [6], in 2017 60,444,228 tons of coconut were produced in the world, and the production in Brazil in the same year was approximately 2,210,139 tons.

Agro-industrial waste has become an environmental problem and natural fibers have therefore gained space in the reuse of waste due to their characteristics and possibilities of improving the mechanical properties of their products [7]. Understanding the properties of coconut waste is important for the development of composites reinforced with this type of fiber. Among the characteristics of coconut waste are low cost, high lignin content, low density, availability, high elongation at break, and low modulus of elasticity [8]. Based on the data presented by [6], it is possible to observe that the production of coconut and consequently the availability of its residues are concentrated in the Asian continent (53 million tons), followed by the American continent (4.9 million tons) and Oceania (2.1 million tons). The countries with the highest coconut production are, respectively: Indonesia, Philippines, India, Sri Lanka, Brazil, Vietnam, Mexico, Papua New Guinea, Thailand, and Malaysia. Therefore, in places where product availability is low, costs must be taken into account and analyzed if there is a good cost-to-benefit ratio. Coconut fiber has in its structural characteristics with suitable thermal and mechanical conditions and can provide various applications in the construction industry [4].

Used since the beginning of civilization, fibers have found new applications in advanced materials due to their characteristics [9]. Natural fibers have the advantage, besides the reduced cost, of being light in weight, with acceptable specific strength properties, high tenacity, and giving better thermal properties to the materials in which they are applied. Among these materials construction products, automobiles, infrastructure, sporting goods, industrial transportation, and consumer applications can be highlighted [10]. The construction industry is responsible for over 30% of the extraction of natural resources, besides 25% of the solid waste generated worldwide [11]. Therefore, the industry is seeking to make its production processes more sustainable, reducing environmental impacts and the use of natural resources [12]. In this respect, it has great potential for the reuse of solid waste, such as in the partial substitution of raw materials for making cement-based materials [13] with natural fibers, as shown in studies [14–16]. In the civil construction industry, it is possible to find natural fibers applied in soil stabilization, infrastructure, bridges, reinforced concrete, and structural reinforcement mortars [17]. The addition of fibers to soil-based building materials has the benefits of improving tensile strength, ductility, impact resistance, city, and reduction in drying shrinkage [18].

The addition of date palm fibers and wood chips to soil–cement bricks was studied by [19]. The study analyzed several stages, with different proportions of cement, clay modifier, and residues. The proportions of fibers analyzed were from 0.5% to 1.5% of date palm fibers, and 1% to 6% of wood chips. The study showed that curing age, clay modifier, and cement can alter the compressive strength, density, and water absorption of the soil. Date palm fibers and wood chips increased compressive strength and decreased water absorption as well as density. The influence of date palm fibers was more significant on mechanical and physical properties compared to wood chips.

The effects of corn fiber on the mechanical properties of soil–cement brick were studied by [20]. Different proportions of fiber (0%, 0.25%, 0.5%, and 1%) and cement (4%, 8%, and 12%) were analyzed. It was observed that the compressive strength improved with the fiber percentage from 0% to 0.5%, but there was a reduction for the other percentages. Cement content and curing time also influence strength, so the effect of corn fiber on improving compressive strength decreases with increasing cement content and curing time. The tensile strength tests show that the addition of corn fiber showed an increase in the tensile strength in the sample from 0% to 0.25%, but from 0.25% to 1% the increase is little or there is a reduction. The study concludes that the proportion of cement affects compressive strength and tensile strength in splitting followed by curing time and fiber content.

The incorporation of wood ash in soil–cement bricks was studied by [21]. The product, from the textile industry, replaced soil or cement in proportions of 10%, 20%, and 30%. Compressive strength tests, water absorption tests, apparent dry density, and durability tests were carried out, where the results obtained showed a change in the material properties. The proportion that presented the best result was 10% in relation to cement, resulting in better compressive strength, less mass loss, absorption, and density similar to the reference brick.

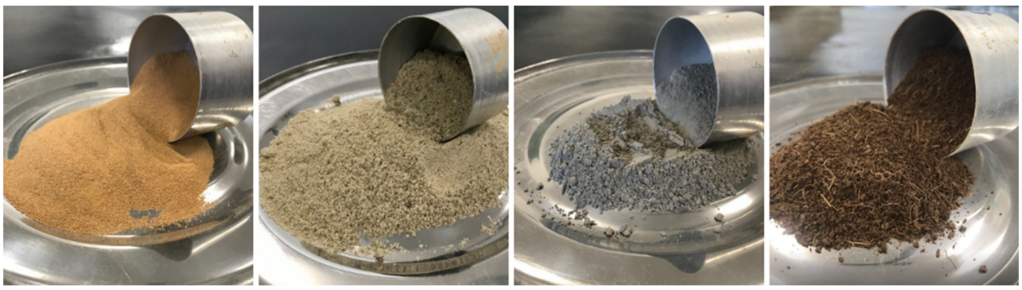
In relation to soil–cement bricks, they are able to improve the mechanical properties, producing sturdy structures ideal for underserved communities in less developed countries [22].

Thus, the objective of this study was to investigate the technological properties of soil–cement brick with the addition of different percentages of coconut fiber powder. It is noteworthy that this research differs from others because it evaluates a particular type of soil that is very recurrent in other regions of the world, and which has enormous exploitation potential for the production of soil–cement bricks. The use of soil–cement bricks is highly advantageous for the civil construction sector, especially in countries with a high housing deficit and an abundance of natural raw materials, such as soil and natural fibers, such as Brazil. Thus, research that deepens the practical knowledge about the development of soil–cement bricks with alternative materials is impacting modern Civil Engineering, and even with unsatisfactory results, this research contributes in a solid way to the development of the state of the art of the theme and improvement of molding techniques and processing of the materials used, this supports the objectives of our research.

2. Materials and Methods

2.1. Materials

The following materials were used for the composition and making of the bricks: soil classified as sandy-clay (Figure 1a), washed sand from the Paraíba do Sul riverbed (Figure 1b), fine sand, Ordinary Portland Cement (OPC) type CP V-ARI (Figure 1c), powdered coconut fiber (Figure 1d), and water, as presented in Figure 1.



(**a**) (**b**) (**c**) (**d**)

Figure 1. Raw materials used: (**a**) soil; (**b**) sand; (**c**) Portland cement; (**d**) coconut fiber.

Regarding the soil, two types of soil samples were collected from the Loteamento Alvorada area in the Jardim Belvedere neighborhood located in the city of Volta Redonda in the state of Rio de Janeiro. Soil sample I was taken from latitude 22°32′16.476″ S, longitude 44°3′46.044″ W, and soil sample II was taken from latitude 22°32′10.968″ S, longitude 44°3′41.472″ W. The samples were subjected to particle size analysis, performed according to NBR 6457 [23] and NBR 7181 [24], which determined which type of soil to use in the study. Thus, 650 kg was collected for the experiment.

The coconut fiber comes from a farm, located in the city of Mojú, Pará state, which is used in the shredded coconut and coconut milk industry. The material was washed with running water to remove the mineral salts and crushed with the aid of a knife mill until a powdery texture was obtained. The coconut waste from the farm was washed to remove salts and granulates and was made available by a distributor located in the city of Rio de Janeiro, in plastic bags. After collection, the waste was quartered and distributed on a plastic tarpaulin and dried in the sun for 48 h to remove moisture.

Fine sand was purchased from a building material store in the city of Volta Redonda, washed, and bagged. Subsequently, the sand was quartered and dried in the sun for 48 h to remove moisture in the external courtyard of the UGB Soil Mechanics Laboratory, located in the Centro Universitário Geraldo Di Biase in the city of Volta Redonda/RJ.

The water used came from SAAE (Serviço Autônomo de Água e Esgoto), located in the city of Volta Redonda/RJ.

2.2. Sample Preparation and Characterization

2.2.1. Soil

The soil was collected manually at a depth of about 80 cm after the topsoil was removed by an excavator. Approximately 20 kg of soil sample I and 20 kg of soil sample II were collected and stored in plastic bags.

Soil samples I and II were distributed on a tarpaulin and dried in the air for 48 h, then crushed and passed through a 4.8 mm sieve, following NBR 6457 [23]. To make the mix more homogeneous, the samples were sieved with a 2.0 mm mesh, thus allowing the removal of gravel. After sieving in the 2.0 mm mesh, soil samples I and II, as well as soil III (soil II corrected with 20% sand), were weighed in a digital balance and their granulometry was performed, following NBR 7181 [24].

Tests were performed to determine the Atterberg Limits of soils I, II, and III, where 200 g samples of each type of soil were separated and passed through a 0.425 mm mesh sieve to perform liquidity limit (LL) and plasticity limit (LP) tests, based on NBR 6457 [23], NBR 6459 [25], NBR 7180 [26].

As determined by NBR 10833 [27], the LL should be less than or equal to 45% and the plasticity index (PI) less than or equal to 18%, making it possible to determine the PI (Equation (1)).

$$PI = LL - LP \tag{1}$$

After the results were obtained, it was determined that soil III was ideal for the study, and the chosen soil compaction test was performed according to NBR 7182 [28], which defined the maximum dry specific weight and optimum soil moisture content. A sample of 3 kg of soil was selected, which was air-dried, crushed, and sieved in a 2.0 mm mesh to meet the standards established for making the brick. Subsequently, the sample had 20% of its weight replaced by fine white sand to adjust the proportions of clay and sand in the soil.

The soil was moistened with distilled water and gradually placed, with the help of a shovel, inside a cylinder, the volume of which had been calculated previously. Every three layers of soil were compacted using a tamping ram and 25 blows. Grooves were made between the compacted layers for better adherence between them. The top of the cylinder was removed, and the excess soil was removed for leveling with the base of the cylinder.

The cylinder body with the compacted soil was weighed on a digital scale, and the weight of the empty cylinder was subtracted from the weight measured, thus obtaining the wet weight of the compacted soil. The specimen was removed from the mold through the extractor, divided into three parts, and the central part was collected. Then, the sample was weighed and taken to an oven with a temperature ranging from 105 °C to 110 °C, according to NBR 7182 [28]; after repeating the process 5 times, it was possible to obtain a soil compaction curve.

2.2.2. Coconut Fiber

To characterize the coconut fiber, NBR NM 248 [29] was adapted in order to perform a particle size analysis of the waste. For classification, the sieve series for fine aggregate was used, these having 2.40 mm, 1.20 mm, 0.60 mm, 0.30 mm, and 0.15 mm mesh, and the remaining waste from the background (Figure 2):

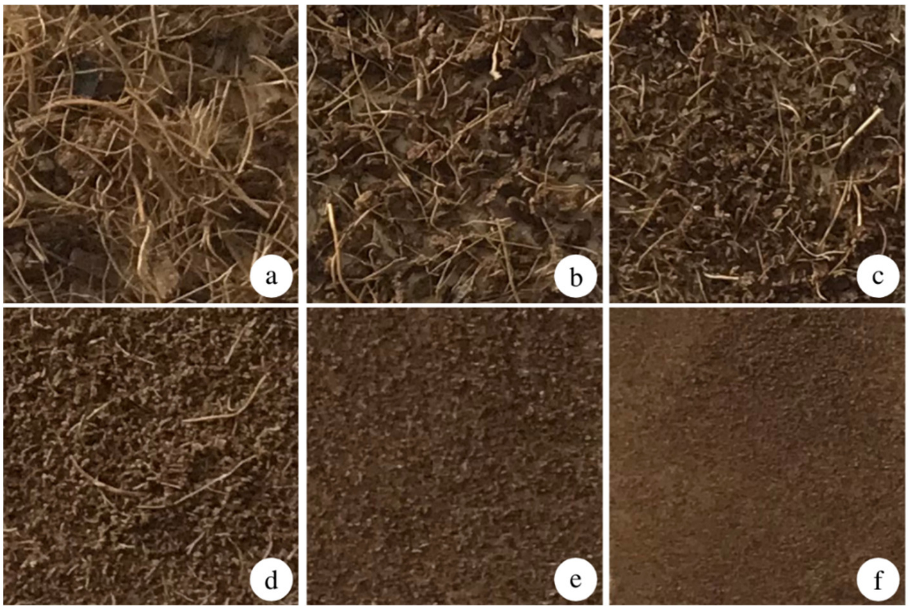


Figure 2. (**a**) Waste retained-mesh 2.40 mm; (**b**) waste retained-mesh 1.20 mm; (**c**) waste retained-mesh 0.60 mm; (**d**) waste retained-mesh 0.30 mm; (**e**) waste retained-mesh 0.15 mm; (**f**) background waste.

2.3. Manufacturing of the Bricks

The mixture used for making the bricks was 1:10, with the replacement of powdered coconut fiber in the proportions of 5%, 10%, and 15%, by volume of soil, in relation to the reference mix without the addition of waste (0%), as presented in Table 1. Soil correction took place in such a way as to previously replace 20% of the soil volume with fine white sand.

Table 1. Mixture used.

Coconut Fiber (%)	Cement:Soil:Waste (Volume)
0	1:10:0
5	1: 9.5:0.5
10	1: 9:1
15	1: 8.5:1.5

To produce the bricks, the instructions of NBR 10833 [27] were followed. The soil was placed in a Prática brand concrete mixer with a capacity of 120 L, crushed and sieved, and then the sand was added. The cement and coconut fiber powder were added after soil correction and mixed until homogeneous. The water was added gradually through a manual sprayer with a capacity of 2 L, mixing the materials until reaching the ideal moisture content (Figure 3a–c). The ideal moisture content of the mixture was reached after adding 8 L of water per mix.

The mixture was then immediately transferred to the loading box of the hydraulic press ECO PREMIUM 2700 (ECOMÁQUINAS, Navegantes and Brazil), to be conducted to the mold box (Figure 4a). With a vertical movement, the press dispensed a force of 6 tons, compacting the mixture into the mold measuring 30 cm $\times$ 15 cm $\times$ 7.5 cm (Figure 4b,c), in which 120 bricks were made (Figure 4d).

(**a**) (**b**) (**c**)

Figure 3. Steps to prepare the mixture: (**a**) mixing materials; (**b**) water addition; (**c**) optimum moisture.

(**a**) (**b**) (**c**) (**d**)

Figure 4. (**a**) Loading box; (**b**) mold box; (**c**) demolding; (**d**) soil–cement brick.

2.4. Curing the Bricks

The brick was removed from the machine and stored on a flat, smooth surface in the shade. The curing process of the brick was carried out through ambient curing at 25 °C, according to NBR 10833 [27], which determines that in the first 7 days after molding the brick should be kept moist. The bricks were wetted during two periods of the day throughout the curing period by means of a hose with a sprayer in order to help the hydration of the cement.

2.5. Technological Tests

2.5.1. Compressive Strength

For the mechanical compressive strength tests, the curing ages of 7, 21, and 28 days were analyzed after molding, with 7 bricks of each mixture, as recommended by Brazilian standard NBR 8492 [30]. The samples were measured with the aid of a pachymeter and cut in half using an electric saw, in the transverse direction, according to NBR 8491 [31] and NBR 8492 [30].

Following NBR 8492 [30], the samples had their parts cut overlapping and joined by a cement paste, the tops of the recesses were removed, and capping was performed using cement paste with a thickness of 3 mm. The drying process lasted 24 h, and then the samples were taken to the test.

The bricks were immersed in water for 20 h to ensure their saturation and then dried with a slightly damp cloth and taken to a CONTENCO 100-ton digital electric press (I-3025-B) (CONTENCO, São Paulo and Brazil), with uniform load application at 50 kgf/s. The capping allowed the load to be applied uniformly and the result of the average resistance was obtained through the arithmetic mean of the 7 specimens (Figure 5).

(a) (b) (c) (d)

Figure 5. (**a**) Brick capping; (**b**) brick submerged in water; (**c**) compressive strength; (**d**) brick after compression.

2.5.2. Water Absorption

To determine water absorption, 3 bricks of each mixture were used, after 28 curing days, following the Brazilian standard NBR 8492 [30]. The samples were placed in an oven until they reached mass consistency at a temperature ranging from 105 °C to 110 °C. After removal from the oven, the specimens were weighed and when they reached room temperature, they were transferred to a water tank for 24 h. Then, they were removed from the water and superficially dried with a slightly damp cloth and taken for weighing.

The information obtained from the test was applied to Equation (2), following NBR 8492 [30]:

$$A(\%) = \frac{(m2 - m1)}{m1} \times 100 \quad (2)$$

where A is the water absorption (%), m1 is the dry mass of the specimen (g), and m2 is the mass of the saturated specimen (g).

2.6. Statistical Analysis

Statistical analyses were performed for the 4 treatments (0, 5, 10, and 15% of fibers), with 7 replications for each treatment (for the compression tests) and 3 replications for each treatment (for the water absorption tests), totaling 28 bricks for compression tests and 12 bricks for abortion tests. A single factor or one-way ANOVA was used to test the hypothesis if there is a significative difference between the means obtained through the different treatments (fibers powder fractions):

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots = \mu_k$$

$$H_{alt} : Meansarenotallequal.$$

where the hypotheses H_0 is accepted (means may be considered equals) if $F_{calculated}$ (using ANOVA method) is lower or equal $F_{critical}$ (obtained from the Fisher–Snedecor table, with 95% of confidence). On the other, If H_0 is rejected ($F_{calculated} > F_{critical}$), H_{alt} is accepted instead, which means that the means are not all equal.

3. Results and Discussion

3.1. Particle Size Analysis (Soil and Coconut Fiber)

The results obtained, following NBR 7181 [24], through particle size analysis of soils I and II, are presented in Table 2, as well as the analysis of soil III, which represents soil II corrected with 20% sand.

The ideal soil for the production of soil–cement bricks must have between 50% and 90% of sand in its composition [32]. Soil I had 46.38% of sand in its composition, outside the ideal standards for making bricks. The granulometric analysis performed on soil II showed 51.85% of sand in its composition, thus being within the standards, but close to the limit value.

Table 2. Soil particle size.

Particle Size Composition	Soil I (%)	Soil II (%)	Soil III (%)
Coarse sand	12.71	11.68	15.50
Medium sand	13.58	22.10	28.00
Fine sand	20.09	18.07	19.30
Silt	5.58	2.95	2.90
Clay	48.04	45.20	34.30

In order to adapt the soil to the necessary characteristics for the soil–cement mixture, a granulometric correction was carried out with fine white sand. Based on the results obtained by the granulometric analysis (Figure 6), soil III (soil II + 20% sand) was defined as an ideal soil, having 62.80% of sand and thus meeting the ideal percentage. The corrected soil was classified according to the Ferret diagram as sandy-clay soil. The granulometric curve presented in Figure 6 shows that the standards recommended by the Brazilian Association of Portland Cement [32], between 50% and 90%, are in agreement with the results found in soil III.

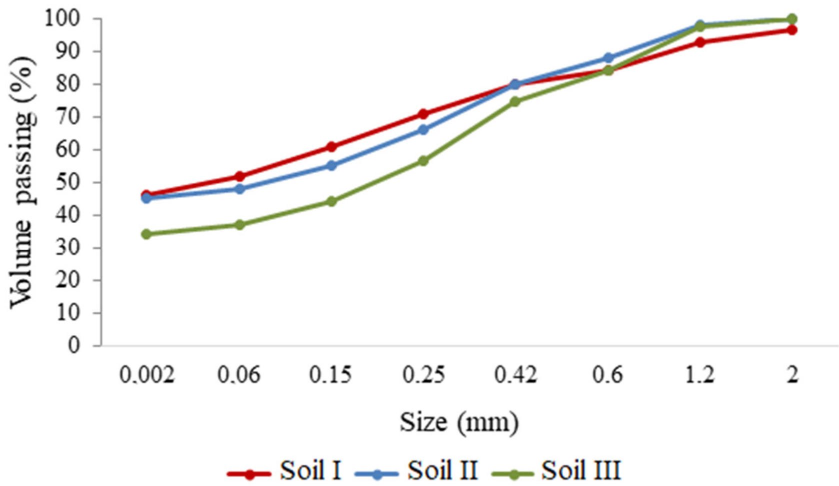


Figure 6. Particle size analysis of soil samples.

Among the authors who used a similar soil composition were [33], who used a soil with a granulometric composition of 66% sand and 34% silt and clay in the manufacture of compressed earth blocks; and [34] who analyzed three types of soil for the production of lateritic soil–cement blocks, soil I with 53% sand, 36.1% silt and 10.9% clay, soil II with 58.3% sand, 32.3% silt and 9.4% clay and soil III with 64.5% sand, 21.1% silt and 14.3% clay. The results obtained in these studies show that the percentage of sand, silt, and clay found in the present study is adequate.

The result obtained by the granulometric analysis of coconut fiber was used as a reference standard for granulometric analysis of aggregates NBR NM 248 [29]. Using the series of fine aggregate sieves, it was possible, according to NBR NM 248 [29], to classify coconut fiber as fine aggregate (fine sand).

3.2. Atterberg Limits

Soil sample I obtained a liquidity limit of 39%, a plasticity limit of 21.2%, and a plasticity index of 17.8% as a result. Soil sample II had a liquidity limit of 46%, a plasticity limit of 22.7%, and a plasticity index of 23.3%. Soil III–soil II corrected with 20% sand presented a liquidity limit of 38.8%, a plasticity limit of 20.8%, and a plasticity index of 18%.

According to NBR 10833 [27], the results obtained in soil I and III are within the recommended limits, with LL less than or equal to 45% and PI less than or equal to 18%, but soil II exceeded the recommended values.

Therefore, when comparing the results obtained in the Atterberg limit tests, where soil I and III are recommended, and the results obtained in the granulometry tests, it was chosen to use soil III to obtain a higher percentage of sand in its composition.

3.3. Moisture Content and Compaction Energy

Subsequently, the soil compaction test III was carried out, which showed the relationship between the specific mass of the soil used and the amount of water added (Figure 7).

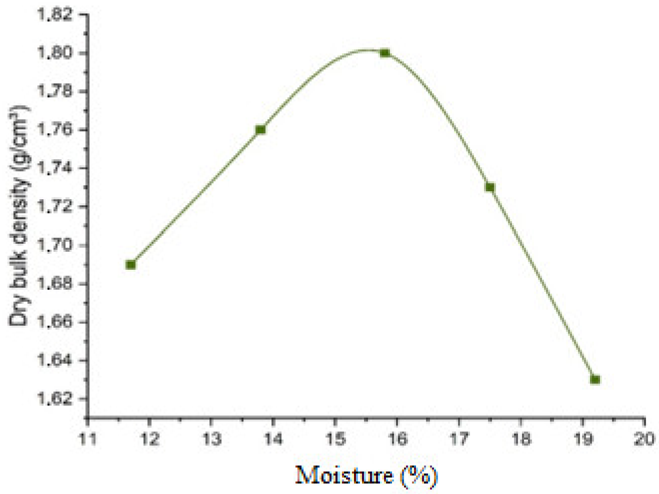


Figure 7. Soil compaction.

According to the graph, as the specific mass increases, the amount of water needed also increases until reaching the maximum moisture limit for a given mass. From the moment that this moisture level is reached, there is a falling behavior due to soil saturation. Thus, the test performed according to NBR 7182 [28] allowed us to find the maximum point of optimal soil moisture of 15.8%, and the optimal dry density of 1.80 g/cm^3.

Having found these parameters, it can be said that they collaborate to find the ideal soil compaction mixture for soil–cement mixtures, in order to reduce voids and improve the material's resistance, since the moisture parameter is decisive for good material resistance results [35].

3.4. Compression Strength

Figure 8 shows the evolution of the compressive strength of the bricks with the curing process. A general behavior that can be observed is the strength increasing with curing time (as expected) and a decreasing dispersion of the strength data (for all fractions of fibers). For the curing times of 5 and 21 days, it can be observed a great variation in the results while for the age of 28 days the variation is lower.

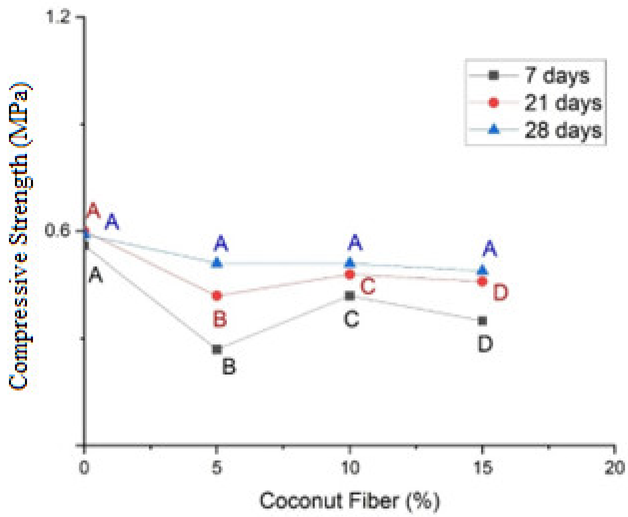


Figure 8. Mechanical compressive strength (MPa). Different letters on the line mean that there was a statistically significant difference.

Table 3 presents the strength of the bricks after 28 days, for the different fiber fractions (7 samples for each treatment).

Table 3. Compressive strength.

Fiber %	CP 01 (MPa)	CP 02 (MPa)	CP 03 (MPa)	CP 04 (MPa)	CP 05 (MPa)	CP 06 (MPa)	CP 07 (MPa)	Average (MPa)	St. Dev. (MPa)
0	0.760	0.620	0.610	0.540	0.540	0.540	0.500	0.587	0.087
5	0.648	0.519	0.355	0.579	0.325	0.587	0.567	0.511	0.123
10	0.441	0.450	0.491	0.544	0.476	0.618	0.569	0.513	0.066
15	0.445	0.438	0.517	0.495	0.382	0.703	0.483	0.495	0.102

The results obtained in the analysis of variance (ANOVA), with 95% of confidence, for the compressive strength after 28 days (data present in Table 3), showed that there is no significative difference between the averages for the different fibers fractions analyzed ($F_{=1.27} < F_{crit=3.0}$).

None of the samples reached the average value determined by NBR 8492 [30], which recommends an average value of 2.0 MPa or an individual value of at least 1.7 MPa for compressive strength. This may have been due to the curing process used, that is, ambient curing [36], which hampered the cement hydration process, since it is directly linked to the type of curing used in the production of soil–cement bricks [37].

The low results obtained may be associated with the fact that the water did not react properly with the cement grains due to the reduced amount of water needed during the curing process [36,38].

The drop in strength due to the addition of fibers may be due to the increase in voids provided by the addition of coconut waste. Although the fiber promotes greater adhesion to the soil–cement matrix, the result obtained in the granulometric test of the waste showed that the fiber acts as a fine aggregate (fine sand). However, it does not have the same resistance characteristics presented by common sand, thus creating voids in the brick structure that do not have significant characteristics for it.

The creation of voids was also observed in cementitious composites incorporating fragmented rubber [39]. In addition, the properties of natural fibers tend to hinder cementitious materials, due to the low chemical compatibility expected between the vegetable fiber and the alkaline content in the matrix [40,41].

The proportion of cement is directly linked to the compressive strength, followed by the curing of the bricks and the fiber waste [20]. The fact that neither the reference brick (without the addition of fibers) nor the bricks with waste reached the determined strength may be due to the trace used having a low proportion of cement, combined with the interference suffered in hydration due to the curing process.

3.5. Water Absorption

Figure 9 shows the data of the average values obtained through the absorption test after 28 days of curing the bricks. It was possible to observe a significant difference in the absorption of the bricks compared to the reference brick (0% fiber), which showed a gradual increase in absorption according to the increase in waste added to the trace.

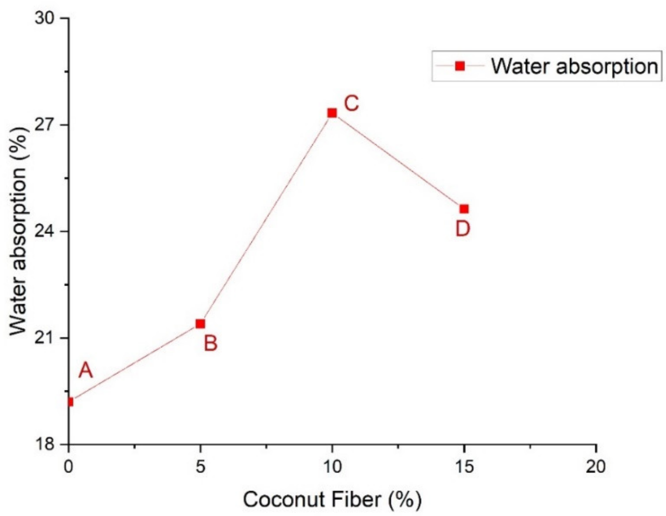


Figure 9. Water absorption (%). Different letters on the line mean that there was a statistically significant difference.

NBR 8492 [30] determines that the absorption of the brick must have an average lower than or equal to 20%, or not have individual values greater than 22%. The voids formed in the brick by the coconut fiber powder contributed to the increase in absorption, proportional to the amount of fiber added. Therefore, the reference brick reached the limits determined by the norm, presenting an average of 19.20% of absorption, and the brick made with 5% of waste reached the limits determined by the norm, having individual values of 21.20% (sample 1), 21.20% (sample 2), and 21.80% (sample 3). Bricks made with 10% and 15% showed high water absorption that did not meet the standards determined by the norm.

The dry weight obtained through the absorption test shows the weight loss proportional to the addition of fiber in the mixture, due to the fact that coconut fiber has a lower specific weight than the soil that it replaced.

The observed increase in moisture content is shown in studies that explain this by the hygroscopic capacity of lignocellulosic materials [42]. The easy absorption of water by plant fibers can negatively influence the mechanical properties of cement composites [43].

4. Conclusions

Based on the results obtained in the present work, the following conclusions can be drawn:

The granulometric analysis of the soil samples determined that the ideal soil to use in the study is soil III, taking into account the composition and amount of sand present, in addition to the limits of liquidity and plasticity.

The incorporation of powdered coconut fiber in soil–cement bricks resulted in a decrease in compressive strength and an increase in water absorption correlated with the fiber fraction and the fact that they have a hydrophilic character.

As concerns water absorption, only the bricks with 0% and 5% reached the reference values, these being 21.40% (addition of 5% fiber) and 19.20% (without the addition of fiber), where the addition of 5% fiber did not have individual values greater than 22%.

As concerns mechanical strength, none of the strength values reached the values accepted by the current standard, but the strength fluctuated little and in a predictable way in relation to the incorporation of fiber into the brick. Therefore, it can be inferred that, with the improvement of the curing process and the reference mixture, it should be possible to produce bricks within the normative values.

Based on the results obtained in the compressive strength and water absorption tests, the brick with the addition of 5% coconut fiber has greater potential for application as an aggregate.

The study indicates and corroborates the literature on the need to characterize and better understand the type of soil to be studied, as well as the wastes that are added, and that this is also a limitation of the application of this technology on a large scale.

According to the present research, it can be suggested that future studies should focus on an in-depth characterization of the properties of coconut fiber, evaluating the application of other granulometries of coconut fiber in the bricks, as well as evaluating the use of different cement contents in the mixture and the improvement of the curing method to be used.

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