Study for the incorporation of wood ash in soil-cement brick

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Abstract

This study aimed to produce soil-cement brick with wood ash incorporation coming from the textile industry. The wood ash was a partial substitute for soil and cement in the manufacture of bricks. 7 formulations were made with different proportions of substitution: 10%, 20%, and 30%. It was noticed that the substitution of cement by wood ash in 10% resulted in brick with enhanced properties, showing a 20% increase for compressive strength and a reduction of 44% for mass loss, thus, with higher durability and a reduction of water absorption of 3%, when comparing to the reference brick (soil-cement). It was shown that the reuse of wood ash in the production of soil-cement bricks is a viable and sustainable option, as it is an alternative for the destination of the waste and a reduction in the consumption of Portland cement, which generates a high volume of carbon dioxide (CO_2) during its production.
Keywords: sustainable materials, soil-cement brick, wood ash.

INTRODUCTION

The civil construction sector is of great importance for humanity because there is an economic investment linked to it in society. Along with this growth, the need to produce sustainable materials arises, which meet technical requirements, as well as conventional materials, and contribute to the reduction of both solid waste and extraction of natural materials. To do so, it is necessary to better use the waste, whether generated by civil construction itself or waste from other segments, such as industrial waste. The demand for cement in the construction industry promotes production and is a determinant of the cement subsector's energy consumption and CO_2 emissions. Initial estimates suggest that 4.1 Gt of cement was produced globally in 2019. Adopting material efficiency strategies to optimize cement use would help reduce demand across the entire construction value chain, helping to reduce CO_2 emissions from cement production. The reduction in cement demand can be achieved through actions such as optimizing the use of cement in mixtures [1].

It is known that many industries adopt the generation of energy in the form of heat by burning wood, thus producing a large amount of waste, including wood ash [2]. Researchers have been improving their studies, demonstrating the possibility of using wood ashes in construction materials, presented as an opportunity for reuse from the study of its physical-chemical and mineralogical composition [3]. Researchers analyzed 11 types of wood ash and recorded that 10 types of ash showed a predominance of calcium oxide (CaO: 31.5%-79.8%) and one type of silicon dioxide (SiO_2: 57.8%). Based on the physical-chemical characterization of wood ash, this study shows that the ash has the potential for use as supplementary cementitious material in cement-based materials with hydraulic properties. All investigated ashes have low or no pozzolanic potential. The opposite trend is observed for hydraulic activity, which can cure and harden, submerged in water, forming cementitious products in a hydration reaction. Only 3 of the investigated ashes met the filing limit. Therefore, it is expected that they contribute to the compressive strength through the filling effect. These divergences between the results found by the researchers are related to the type of ash used, which in turn depends on the burned biomass and the combustion process (temperature and technology) [4].

Studies show that it is possible to prepare light bricks made from ground soil, textile sludge, and coal ash. It was possible to produce bricks with a compressive strength of 13.7 MPa, apparent specific gravity of 1.47 g/cm^3, water absorption of 14.6%, and volumetric contraction of 13.61%, after sintering [5]. However, the incorporation of wood ash, as a partial replacement of cement, interferes with the workability of the material [6]. Ribeiro [7] used wood ash from the burning process of the red ceramic industry to be incorporated into soil-cement bricks, from 10% to 40% of substitution, only for cement. The results match the values recommended by NBR 10834 standard [8] for compressive strength, and for individual values of water absorption below 22%, in the proportions of 10% and 30%. The incorporation of 30% showed the most satisfactory results. To determine the properties studied, the author produced cylindrical specimens and suggested, as future research, the manufacture of soil-cement bricks incorporated with wood ash. Among the materials that enable the incorporation of waste are the soil-cement bricks [7, 9-16], obtained from the mixture of soil, cement, and water. Brick is one of the basic components of civil construction, no matter the type, location, or class. However, conventional brick is very damaging to the environment with its manufacturing process, due to the kilns for cooking [17]. In contrast,

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there is the soil-cement brick, which in its manufacturing process, drying is done only naturally, thus minimizing energy consumption, in addition to being an alternative material [18]. Among the advantages of using soil-cement, there are the simple technology, availability of soil in the regions, the possibility of corrections in its granulometry, thermal and acoustic comfort, durability, reduction of maintenance, besides elimination of constructive steps, such as roughcasting and plastering.

In order to contribute to the expansion of studies that include sustainable materials, and considering the scarcity of research that studied the influence of partial replacement of Portland cement and soil by wood ash in the production of soil-cement bricks, adopting the usual manufacturing dimensions and standardized by NBR 8491 [19], therefore, there is no data that validate this influence, thus, this research aims to produce soil-cement bricks incorporating wood ash from the textile industry, considering the predominance of this industrial branch in the municipality of Estância-SE, Brazil. For that, 7 formulations were produced, adopting the reference formulation with a mass ratio of 1:8 (cement:soil). The soil and cement were partially replaced by wood ash in the proportions of 10%, 20%, and 30%. The component materials of the mixture were characterized according to technical standards. The soil-cement bricks were subjected to bulk density, water absorption, compressive strength, and durability tests.

EXPERIMENTAL

Materials applied in the brick composition: CP V-ARI-RS cement (Portland cement of high initial strength with resistance to sulfates) was used. The following tests were carried out with the cement: fineness index [20]; normal paste consistency [21]; setting time [22]; specific gravity [23]; and compressive strength [24]. The soil used in making the soil-cement brick was collected from the ground of the Federal Institute of Sergipe, located in the municipality of Estância, State of Sergipe, Brazil. The soil was deposited in containers for drying in an oven at 110 ºC for 24 h. Subsequently, it was manually ground with a pestle covered with rubber, in the porcelain mortar. Then, the collected soil was separated through a 600 μm sieve, in order to guarantee ideal plasticity for brick molding. The material was deposited in closed containers to not absorb moisture from the air, until the time of use. Following the general requirements of the NBR 10833 standard [25], the following characterization tests were performed: granulometric analysis [26]; apparent [27] and real specific gravity of the soil [28]; liquidity index [29]; and plasticity limit [30]. The scanning electron microscopy (SEM) of the soil and wood ash was performed using a microscope (JSM-6510LV, Jeol). Chemical composition was determined using semi-quantitative measurements using the X-ray fluorescence (XRF) technique. The measurements were carried out in a vacuum, with a spectrometer (Primini EZ Scan, Rigaku), using samples with a mass of around 12 g, which were pressed in the shape of cylindrical bodies with a diameter of 60 mm and a thickness of approximately 5 mm. X-ray diffraction (XRD) was used to identify the crystalline phases of the materials. The experimental patterns were obtained from 5° to 70°, using a diffractometer (D-MAX 100, Rigaku) with CuKα_1 radiation (λ=1.5418 Å) in continuous scanning mode with a speed of 1 °/min. The wood ash used in this research came from the burning process of eucalyptus wood, removed from industrial power boilers, fed on an energy biomass base (wood). It was supplied by Atual Têxtil, located in the city of Estância-SE, Brazil, and specialized in the fabrication of knits and fabric trade in general. According to the company, it is estimated that around 30 kg of wood ash is produced daily. The material was collected in a fine powder form, deposited in containers, and placed in an oven for 24 h at 110 ºC. Then, it was sieved at aperture sizes of 1.18 mm (replacing the sand used in soil correction), 600 μm (replacing the soil collected), and 75 μm (replacing the cement), which were used in the characterization tests and in the production of soil-cement bricks. The characterization of the waste was carried out adopting the standards used in the tests of soil and cement.

Dosing and sample preparation: from the granulometric analysis of the collected soil, it was found that it was a very clayey one, with low compressive strength required for bricks and thus, needed correction. Therefore, after carrying out several experimental tests, it was determined that the soil used as a reference should be corrected with 70% of sand (to ensure a better surface finish on the brick, the sand passing in the 1.18 mm sieve was adopted), with a moisture content of 14%. It is important to highlight that soils rich in sand and with low plasticity are the most suitable to produce soil-cement bricks, as they stabilize with less cement [11]. Seven formulations were produced, according to Table I, adopting the reference formulation with a mass ratio of 1:8 (cement:soil). In the formulations $T_{s10\%}$, $T_{s20\%}$, and $T_{s30\%}$, the soil was partially replaced by the wood ash and the mixtures had a varying percentage of water. As the amount of wood increased, the mixture was drier, thus making the pressing unfeasible. In the $T_{c10\%}$, $T_{c20\%}$, and $T_{c30\%}$ formulations, the cement was partially replaced by the same wood ash, but without the need for moisture variation. The bricks were produced using a manual press (Tec11, TecMaquinas). For each formulation, 13 bricks with dimensions of 25x12.5x6.5 cm were molded, meeting the specifications of the NBR 10834 standard [8]. The mixing was carried out manually: first, cement, soil, and wood ash were mixed, and later, water was added with the aid of a sprinkler. After carrying out this process, 3700 g of the mixture of each brick were weighed for pressing, determined after attempts to obtain the maximum amount of mixture possible to be pressed manually. With the bricks made, 7 bricks were separated to perform the compressive strength test, 3 bricks for the water absorption test, and 3 bricks for the durability test and their respective bulk density. After pressing, the bricks were placed in a rectangular container and then placed on a flat surface for curing, where they remained for 7 days, protected from the wind and direct sunlight. For the dimensional analysis of all 13 bricks produced, a tolerance of ±1 mm for length, width, and height was verified.

Table I - Formulations of soil-cement bricks.

Code	Composition (mass ratio)			Moisture (%)	Replacement by wood ash (%)
	Cement	Soil	Wood ash		
Ref.	1.0	8.0	-	14	-
$Ts_{10\%}$	1.0	7.2	0.8	14	10
$Ts_{20\%}$	1.0	6.4	1.6	18	20
$Ts_{30\%}$	1.0	5.6	2.4	20	30
$Tc_{10\%}$	0.9	8.0	0.1	14	10
$Tc_{20\%}$	0.8	8.0	0.2	14	20
$Tc_{30\%}$	0.7	8.0	0.3	14	30

Characterization tests of bricks in the hardened state: after 7 days of curing, the bricks were subjected to characterization tests in the hardened state, according to NBR 10834 [8] and NBR 13554 [31] standards. For the analysis of the results obtained in the tests, the normality of the data was verified, and statistical analysis was carried out through the analysis of variance (ANOVA), followed by the Tukey test. To perform the compressive strength test, the 7 bricks were capped according to NBR 8492 standard [32] and cut in half perpendicularly to the largest dimension, as shown in Fig. 1. After 12 h and total hardening of the cement paste, the prisms were broken in a press (HD-200T, Contenco) used to perform the compressive strength test. The water absorption test was determined according to NBR 8492 standard [32]. After curing for 7 days, the bricks were placed in the greenhouse for 24 h and then weighed, obtaining their dry weights. Then, after reaching room temperature, they were submerged in water for the same period and weighed to obtain their saturated weights. The dry bulk density of the specimens was determined by the relationship between the mass of the ceramic body (g) and its volume (cm^3). The durability test was carried out according to NBR 13554 standard [31] using 3 specimens, in which the test consisted of a cycle of 48 h, between wetting and drying, with 6 repetitions.

Figure 1: Preparation of the bricks for the compressive strength test.

RESULTS AND DISCUSSION

Physicochemical characterization of the materials used in the composition of the bricks

Table II presents the results found for cement, wood ash, and mixtures of cement with wood. The wood ash used in this composition was the one collected after the sieving process (75 µm). It is possible to identify that the wood influenced the start time of setting determined for the cement and adopted for the mixtures, for a water percentage of 35%, but still within the limits established in the standard (<60 min). The reduction in setting time can be explained by the predominant presence of calcium oxide (CaO: 69.64%) in wood ash, which is important for the formation of calcium hydroxide, capable of accelerating the hardening process of the mixture [7]. Fresh mortar made with wood ash tended to harden quickly, as noted by other authors [33]. The compressive strength gradually decreased as the amount of wood ash increased. In addition to significantly reducing the percentage of cement in the mixture, which is the main constituent responsible for the development of mechanical strength, such behavior was also consistent with the study by Cheah and Ramli [34]. In that study, it was observed a trend of mortars' compressive strength reduction as the replacement of cement by ash increased, probably due to the mechanism of action of the wood ash particles acting more as a filling material within the cement paste matrix than as a binding material. The specific gravity did not vary significantly as the wood ash was added. The granulometric curve of the raw materials and their mixtures are plotted in Fig. 2, with all materials classified as well-graded and moderately uniform, considering the uniformity and curvature coefficients. Thus, it was verified that the corrected soil and its mixtures met the normative criteria, presenting a size fraction of less than 75 µm of at least 10%. The mixture with substitution of 30% of the wood ash presented a greater amount of fine material (21.61%), due to the granulometry of the wood, which had a higher percentage of fines (27.19%) compared to the soil (12.03%).

In the chemical composition analysis of sandy soil, presented in Table III, there was a predominance of silica (SiO_2: 89.33%) and, in a smaller percentage, aluminum oxide (Al_2O_3: 7.17%), as seen in the X-rays diffractogram (Fig. 3a) and the scanning electron micrography of the soil used in this research (Fig. 4a). These results validated the predominance of quartz, which was expected, considering that the collected soil was corrected with 70% of sand. Also, characteristic peaks of illite and feldspar were registered. Other authors found similar results [7, 14].

Table II - Results of characterization obtained for cement, wood ash, and mixtures of cement with wood ash.

Property	Cement	Wood ash	Cement + 10% wood ash	Cement + 20% wood ash	Cement + 30% wood ash
Normal consistency paste (wt%)	35	35	35	35	35
Initial setting time (min)	140	-	78	96	93
Compressive strength, 7 days (MPa)	34.25	-	30.99	26.05	18.98
Fineness index (%)	0.08	0	0	0	0
Specific gravity (g/cm^3)	3.037	2.556	3.063	3.033	2.952

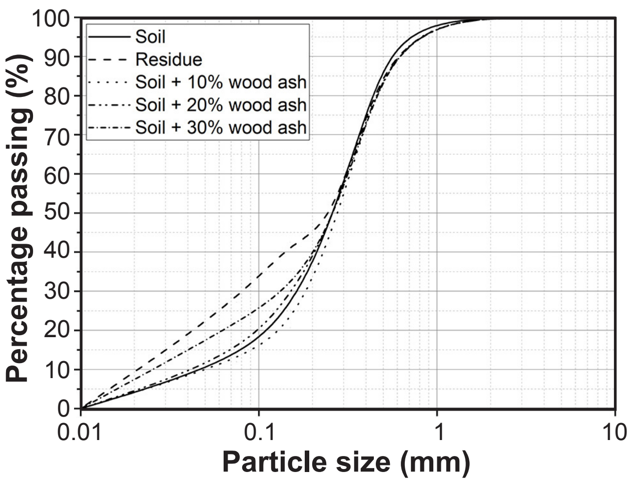

Figure 2: Granulometric curves of the soil, wood ash, and mixtures.

Table IV shows the results obtained for tests carried out with the soil and the soil with wood ash. The results found certified that the soil and mixtures met requirements from NBR 10833 standard [25], resulting in a liquid limit LL≤45% and plasticity index PI≤18%. The studied soil can be classified as a material with low plasticity and, therefore, suitable for soil-cement. Regarding wood ash waste, it was found that the waste was considered a non-plastic material (NP), ideal for use in the production of cement-based soil-cement masses since the wood ash can positively influence technological properties [7]. The wood ash had an apparent specific gravity (Gsa) lower than the soil, which resulted in a reduction in the Gsa of the mixtures. The results found showed that there was no significant variation in the specific gravity when the soil was replaced by the wood ash.

Table III - Chemical compositions (wt%) of soil and wood ash.

Material	SiO_2	Al_2O_3	K_2O	MgO	CaO	SrO	P_2O_5	$FeSO_3$	SO_3	Cl
Soil	89.33	7.17	0.41	-	0.63		-	1.97	0.33	
Wood ash	5.30	1.39	7.42	6.06	69.64	0.42	7.79	-	1.44	0.53

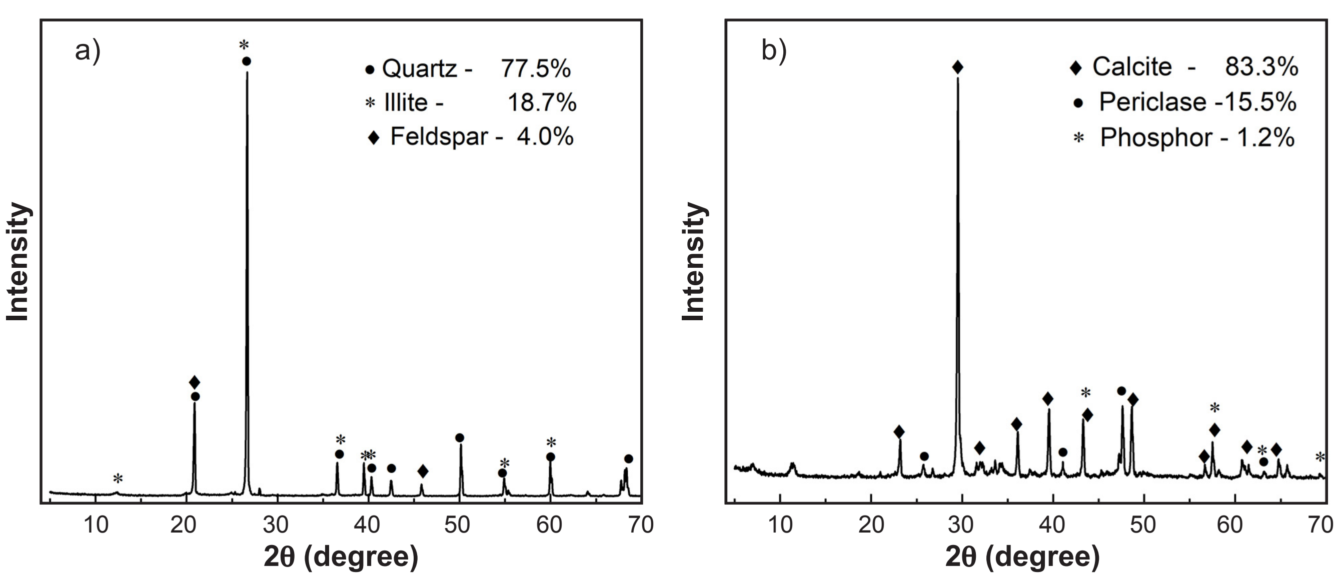

Figure 3: X-ray diffraction patterns of the soil (a) and wood ash (b).

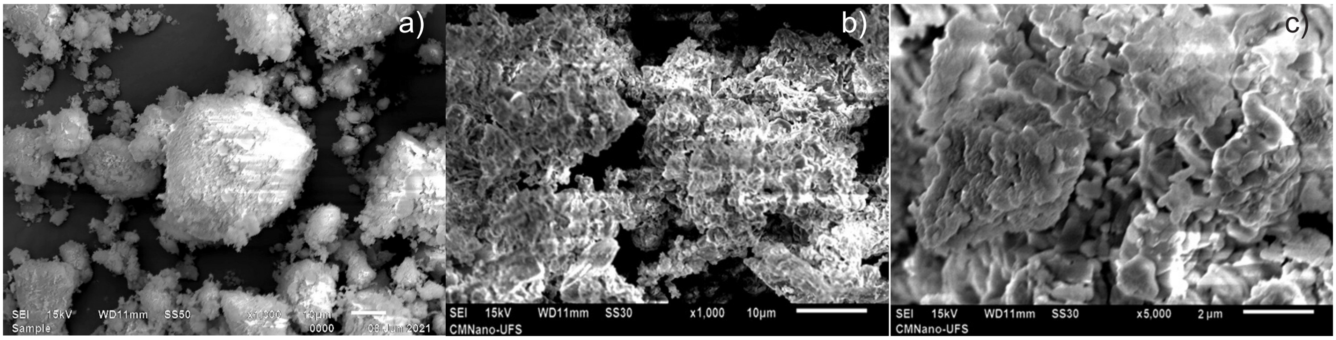

Figure 4: SEM micrographs of the soil (a) and wood ash particles (b,c).

Table IV - Physical characteristics of soil, wood ash, and mixtures of soil with wood ash.

Parameter	Corrected soil	Wood ash	Soil+10% wood ash	Soil+20% wood ash	Soil+30% wood ash
PI	7.34	NP	NP	NP	NP
LL	17.00	-	16.60	13.41	14.05
Gsa (g/cm^3)	1.430	0.563	1.261	1.146	1.206
Gs (g/cm^3)	2.635	2.465	2.702	2.664	2.638

PI: plasticity index; LL: liquid limit; Gsa: apparent specific gravity; Gs: specific gravity; NP: non-plastic.

The chemical composition of wood ash is shown in Table III. There was a predominance of calcium oxide (69.64%) in its composition, similar to other studies that used wood ash from eucalyptus [7, 35]. Hydrated calcium silicates and calcium oxide were the main hydration products of Portland cement [36]. It was noted that wood ash contained 6.69% of SiO_2, Al_2O_3, and Fe_2O_3 and did not meet one of the minimum chemical requirements to be classified as pozzolanic material [37]. Other authors [38], who also used wood ash, found other parameters that did not meet the requirements of the NBR 12653 standard [37]: the loss on ignition of 23.40%, a value greater than 10%. The hydraulic activity of wood ash can be analyzed by the SiO_2 and CaO contents. The EN 197-1 standard [39] states that the mass ratio CaO/SiO_2 >2 confirms this potentiality. Ash used in this research met this parameter and, therefore, indicated that it can be used as a partial cement substitute in cement-based materials, as reported by other researchers [4]. The mineralogical composition of wood ash, determined by XRD (Fig. 3b), showed a predominance of calcite ($CaCO_3$: 83.3%). No amorphous band was observed; if present, the amorphous glass was probably in a limited amount. As other authors have observed, it did not contain any of the typical spherical vitreous aluminosilicate particles found in commercial coal ash. Furthermore, they concluded that the low aluminosilicate content leads to a low pozzolanic activity [4]. The morphological aspects of the wood ash particles were obtained through scanning electron microscopy (SEM), which micrographs are illustrated in Figs. 4b and 4c. It was observed that the wood ash was composed mainly of homogeneous particles, with irregular shapes, similar to previous research [2, 4, 7].

Characterization tests of bricks in the hardened state

Fig. 5a shows the results obtained in the water absorption test, performed at 7 days of age. The results showed that there was a significant difference between the means (F=187.94, $f_{critical}$=2.92, and p-value=$7.3x10^{-12}$); with the Tukey test, significant differences were found. Therefore, for both the soil and the cement, it was clear that there was an increase in the water absorption as the wood ash addition content increased. This may be related to the rough surface of the wood ash, which consequently retained more water in the composition, generating a greater number of voids. Other authors [38] observed that the water absorption of wood ash was 13.3%, a value much higher than that of sand of 0.76% (which corresponded to 70% of the soil composition of the present research). In addition, ash is more porous than quartz sand. In the study by Teixeira et al. [40], it was observed that the highest values of the increasing content of air voids were for mixtures with the incorporation of ashes. Fusade et al. [33] in their study observed that the mortar with wood ash shows a higher amount of capillary pores. The formulation $T_{s30\%}$ showed the highest absorption of 24.2%. However, the other formulations resulted in absorption values lower than that specified in NBR 10834 standard [8], whose average absorption values must be less than or equal to 20%, and individual values less than or equal to 22%, with a minimum age of up to 7 days. It is worth mentioning that $T_{c10\%}$ presented the most satisfactory result, similar to the reference brick.

Fig. 5b illustrates the results of compressive strength of the bricks produced, with replacement of the soil and cement. The results showed that there was a significant difference between the means (F=19.01, $f_{critical}$=2.36, and p-value=$5.91x10^{-10}$); with the Tukey test, it was found a significant difference for $Ts_{10\%}$ and $Tc_{30\%}$, with a 40% reduction in strength compared to the reference brick. In this research, it was not possible to define a pattern of behavior with the addition of ash incorporation to replace the soil. However, it appeared that the $Ts_{20\%}$ presented strength equal

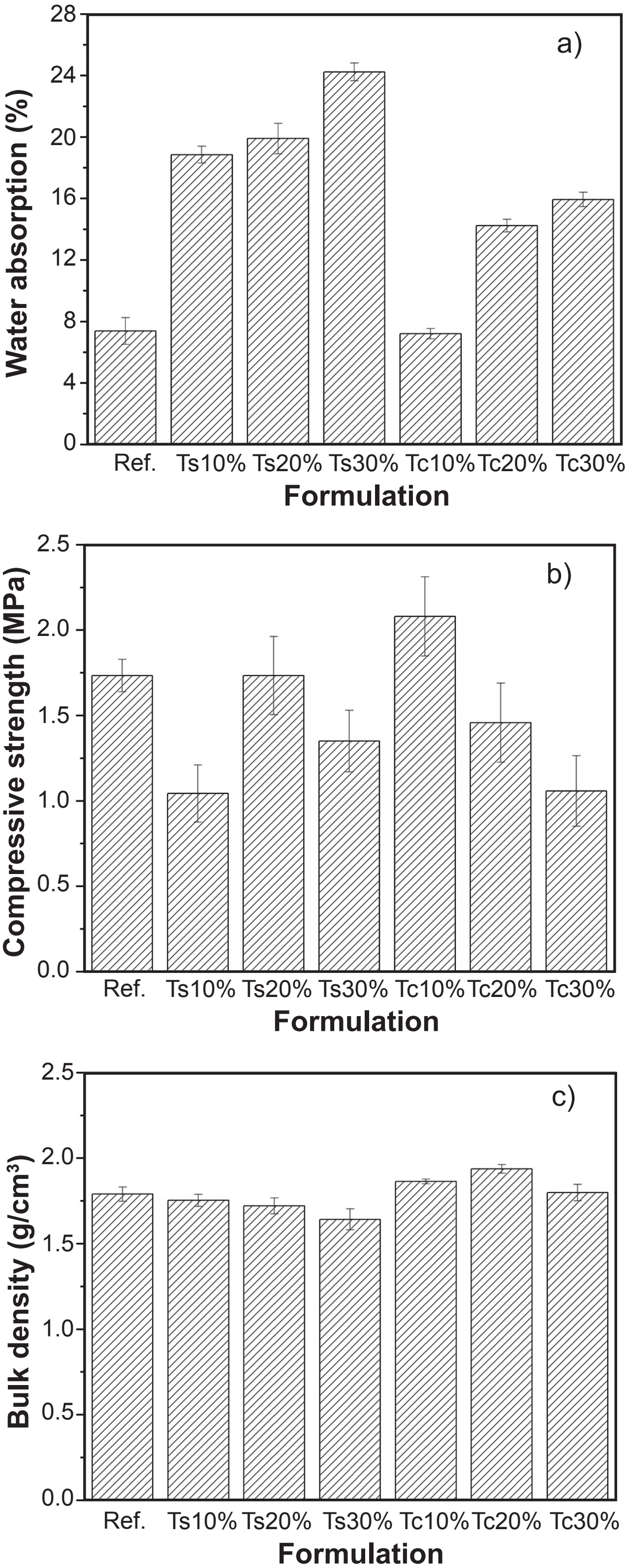

Figure 5: Results of water absorption (a), compressive strength (b), and bulk density (c) of the bricks.

to the reference brick. In bricks with 10% and 30% of soil replacement by wood ash, the compressive strength was reduced in relation to the reference. It may be related to the chemical composition of the soil, where silica predominated, which was partially replaced by calcium oxide, which has lower mechanical resistance. However, with 20% of replacement, the results did not show significant variation. Thus, it can be linked to the indication that the ideal replacement proportion of ash by soil is also an important factor to be considered, since here the ash had a higher filler effect, as reported by Sigvardsen et al. [4] that the addition of ash as filler can still positively influence cement-based materials. An inert filler can contribute to the properties of a cement-based material by filling intergranular voids. Fusade et al. [33] studied the effect of wood ash with a chemical composition similar to this research in repair mortars and observed that 20% of wood ash seems to be a limit for the replacement of aggregates by ash. Still, in the strength activity index (SAI) determination of mortars with wood ash, they found values of 1.25, 1.83, and 1.75 for lime mortars that replaced the aggregate with ash in 10%, 20%, and 30%, respectively, corroborating the behavior found in this research.

In the substitutions of cement for waste, there was a decrease in strength as the incorporation content increased. Other authors [38] have studied that the content of alkalis in wood ashes seems to be a limiting parameter for the use of large quantities as a substitute for cement. In their research, they found that the content of alkalis available in the ash used did not allow the replacement of Portland cement at levels above 17% by weight. Nevertheless, in this research, the $Tc_{10\%}$ formulation resulted in brick with compressive strength superior in 20% to the reference brick, surpassing the requirements of NBR 10834 standard [8], which determines average and individual strengths of 2.0 and 1.7 MPa, respectively. The result of the mechanical performance can be correlated with the chemical composition of the ash. In the research by Acordi et al. [38], they used three types of wood ash with different chemical compositions; it was possible to observe that the highest values of compressive strength occurred with ashes that had a higher content of SiO_2, Al_2O_3, and Fe_2O_3 and lower loss on ignition. On the other hand, for wood ash from the textile industry with similar characteristics to the ash used in this research, the worst result was obtained for the opposite condition. However, this strength has been improved up to 5% by cement substitution, which can be attributed to the lower apparent specific gravity (563 kg/m^3) and high-water absorption (reported in other research [38]), compared to the soil used. Ash, up to 5%, may have helped to increase the compressive strength. This result may be linked to a phenomenon called internal cure, credited to the water retained in the pores of the aggregates and its activities to promote the hydration of cement over time [38]. Teixeira et al. [40] observed that up to 90 days of curing, the reference mortar had the highest compressive strength values. After this period, formulations containing ash replacing cement showed values similar to 100% of mortar with cement alone, indicating that the addition of ash leads to a delay in the hydration process, which leads to a delay in increasing the compressive strength. It was

Table V - Results of mass loss (%) obtained with a durability test.

Ref.	$Ts_{10\%}$	$Ts_{20\%}$	$Ts_{30\%}$	$Tc_{10\%}$	$Tc_{20\%}$	$Tc_{30\%}$
4.5±0.9	8.0±0.7	3.7±1.0	7.2±0.8	2.0±0.9	4.4±2.0	7.2±2.2

observed that, with the increase in the curing time (90 and 180 days), no significant differences were observed between the mortars with ash. The use of ash in construction materials slows down the hydration reaction of the cement and, during the curing time, the calcium hydroxide dissolved in the water present in the mortar reacts with the ash to form solid reaction products that fill the capillary pores, partially or totally.

Fig. 5c shows the dry bulk density of the bricks. The results showed that there was a significant difference between the means (F=10.63, $f_{critical}$=2.85, and p-value=1.6x10^{-4}). The formulations $Ts_{30\%}$ and $Tc_{20\%}$ showed a reduction of 8% in the bulk density of the bricks produced. It appears that the increase in the substitution content, both for cement and soil, did not significantly change the bulk density of the bricks, which can be attributed to the standard mass used for pressing the bricks. Thus, as Teixeira et al. [40], it was not observed significant differences in fresh density between mixtures containing ash. Table V shows the values of mass loss of the bricks, used as a parameter to assess durability. The results showed that there was no significant difference between the means (F=2.56, $f_{critical}$=3.87, and p-value=0.12), adding to this analysis the sample deviation and the reduced number of samples specified in the standard, two bricks for determining the loss of mass. However, all formulations presented a percentage of mass loss within the limit value considered for the construction of soil-cement, which is 10% [41].

Thus, it was possible to verify that the replacement of 10% of wood ash by cement ($Tc_{10\%}$) was the one that resulted in the best compressive strength, less loss of mass, and absorption and bulk density similar to the reference brick. The replacement of 20% of the soil by the wood ash resulted in compressive strength similar to the reference, and acceptable values of loss of mass and absorption, meeting both sustainability and technical criteria. Sustainability as regards the reduction of sand content, cement content, and use of waste, since the manufacture of cement consumes a lot of energy and fossil fuel, which gives rise to large energy and carbon footprints and causes global warming, while sand mining causes considerable ecological risks. Massive depletion of natural sand destroys agricultural land and damages fauna habitat, leading to deficiencies in fresh water and food for humans. In addition, dredging sand from the river basin can potentially destabilize riverbanks and undermine road and bridge landfills [42].

CONCLUSIONS

The influence of the incorporation of wood ash from the textile industry on the properties of soil-cement bricks was studied. The experimental results obtained in this work allowed some conclusions: i) the wood ash, when incorporated into the soil-cement mass, modified the physical, mechanical, and durability properties; there were no cracks or other anomalies in the bricks after the curing process; ii) the incorporation of wood ash in the formulations of soil-cement bricks caused changes in the mechanical properties; substitutions with 10% of the wood ash by cement resulted in greater strength than the reference; however, as the wood ash content increased, there was a reduction on the compressive strength; the substitutions for the soil presented diversified behaviors in relation to the reference brick; iii) all formulations showed a loss of mass less than 10%, ideal for the construction of soil-cement; and iv) the replacement of 10% wood ash by cement ($T_{c10\%}$) was the one that resulted in the best compressive strength, lower loss of mass, and both absorption and bulk density analogous to the reference brick; the replacement of 20% of the soil by the wood ash presented compressive strength similar to the reference, and values like loss of mass and absorption, acceptable. In conclusion, the use of wood ash in the production of soil-cement brick is a viable alternative, considering the properties required for the brick. It contributes to an appropriate destination for waste, reducing the extraction of natural resources. Also, the incorporation of wood ash in substitution for Portland cement contributes to the reduction of carbon dioxide (CO_2) emission, generated during its production.

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