Revista Brasileira de Ciências Ambientais
Brazilian Journal of Environmental Sciences

Lightweight aggregate: a sustainable alternative for reuse of sawdust waste in the industrial process

Agregado leve: uma alternativa sustentável para o reaproveitamento de resíduo de serragem no processo industrial

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ABSTRACT

Sawdust generated by wood processing, both in industries processing and in tree felling, is a waste that has several applications for reuse, but, in many cases, it is still discarded irregularly in the environment, contaminating the soil, air, and water. The production of lightweight aggregate (LWA) can be an option for the reuse of this sawdust. The LWA is a gravel solution used in civil construction with the objective of reducing the weight of the structure, improving thermal and acoustic compliance, or as an option for locations where gravel is not available. In Brazil, and in most parts of the world, there are common clays available that can be used in the LWA production. The aim of this research was to produce an LWA for different applications, among them, as aggregate for civil construction, bricks, and as an adornment element. Formulations were tested to produce LWA containing illitic clay and sawdust. In the same way, for comparison, a commercial LWA was purchased, and formulations were made with clay and coal, and clay and fuel oil. The specimens were produced by pressing at 30 MPa in a cylindrical shape with a diameter of 19 mm and a height of 15 mm. After firing, the specimens were characterized by technological tests of water absorption, bulk density, compressive strength, X-ray diffraction analysis, and chemistry by X-ray fluorescence. The results indicated that the incorporation of sawdust in the formulations can be an alternative to produce LWA, once it obtained high strength and low density, compared to commercial LWA and to that produced with unattractive materials. Furthermore, it may contribute to the reduction of environmental impact, resulting from the disposal of sawdust and the generation of natural resources, necessary to produce construction materials.

Keywords: recycling; building materials; sustainability; waste management.

RESUMO

A serragem gerada no processamento da madeira tanto em lojas moveleiras como na extração de árvores é um resíduo que possui diversas aplicações para reutilização, mas que, em muitos casos, ainda é descartado de forma irregular no meio ambiente, contaminando o solo, o ar e a água. A produção de agregado leve pode ser uma opção para o reaproveitamento dessa serragem. O agregado leve (AL) é uma opção de brita usada em construção civil com o objetivo de reduzir o peso da estrutura, melhorar o conforme térmico e acústico ou, ainda, como opção para locais onde a brita não está disponível. No Brasil e em quase todo o mundo existem argilas comuns disponíveis e que poderiam ser utilizadas na produção de agregado leve. O objetivo desta pesquisa foi produzir um AL para diferentes aplicações, entre elas como agregado para construção civil, tijolos e como elemento de adorno. Foram testadas formulações para a produção de agregado leve contendo argila ilita e serragem. Também, para efeito de comparação, foi adquirido um agregado leve comercial, e formulações feitas com argila e carvão mineral, argila e óleo combustível. Os corpos de prova foram produzidos por prensagem à pressão de 30 MPa, em formato cilíndrico com diâmetro de 19 mm e altura de 15 mm. Após a queima, os corpos de prova foram caracterizados por ensaios tecnológicos de absorção de água, densidade aparente, resistência à compressão, difração de raios X e análise química por fluorescência de raios X. Os resultados mostraram que a incorporação de serragem nas formulações pode ser uma alternativa para a produção de agregado leve, uma vez que se obtiveram alta resistência e baixa densidade em comparação com o agregado leve comercial e os produzidos com materiais não sustentáveis. Além disso, o uso da serragem contribuiu para a redução do impacto ambiental causado pelo descarte desnecessário de serragem e pela extração de recursos naturais, necessários para a produção de materiais de construção.

Palavras-chave: reciclagem; materiais de construção; sustentabilidade; gerenciamento de resíduos.

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Conflicts of interest: the authors declare no conflicts of interest.

Funding: Coordination for the Improvement of Higher Education Personnel and Institutional Program of Scientific Initiation Scholarships of the Instituto Federal de Sergipe.

Received on: 02/14/2023. Accepted on: 06/02/2023.

https://doi.org/10.5327/Z2176-94781555

Introduction

The excessive consumption of materials that are non-degradable or difficult for the environment to assimilate has created increasing challenges in solid waste management, leading to environmental, social, and economic damages that affect all of society. Current waste management systems are overloaded and, when mismanaged, can result in significant costs to public budgets (Bundhoo, 2018). According to data from the Panorama of Solid Waste in Brazil 2020 (Lira et al., 2020), waste generation has increased from 66.7 million tons in 2010 to 79.1 million tons in 2019, representing an increase of 12.4 million tons. Only 59.1% of the collected waste is destined to landfills (Brasil, 2021).

The lack of environmental sustainability, resulting from human activities, represents one of the most significant problems on a global scale. In order to address environmental concerns, the 2030 Agenda for Sustainable Development was established in New York in 2015. In this initiative, members of the United Nations (UN) and major Non-Governmental Organizations (NGOs) made a commitment to implement targets aimed at advancing sustainable development. The Agenda consists of seventeen Sustainable Development Goals (SDGs) and 169 subgoals, aiming to ensure a more sustainable life in economic, social, and environmental terms (Tothova and Heglasova, 2022). This research is aligned with some specific goals such as number eleven, related to sustainable cities and communities, twelve, addressing responsible consumption and production, thirteen, focused on actions against climate change, and fifteen, focused on terrestrial life preservation.

Increasing sustainability is one of the biggest challenges in the construction industry. In this sense, alternative building materials are being developed to mitigate environmental impacts and meet the standards of sustainable development, production and consumption (Silva et al., 2009; Araújo et al., 2019).

According to Bruna and Vizioli (2006), sustainability promotes joint actions in the construction industry to meet human needs, including housing and quality environments for society.

Several pieces of researches are directed to construction materials (including soil-cement bricks), as the one reported by Silva et al. (2021), who studied the incorporation of wastes such as grains from the pulp industry, rice husk, brachiaria grass, steel products with soil blocks, granulated cement and blast furnace slag. Many wastes have shown to be viable in specific proportions, to be used in this type of court, thus being a sustainable alternative, contrary to its improper disposal in landfills and the environment.

According to Viezzer (2022), wood waste is all that is left over from an industrial production process or forest exploitation. Among the wastes generated in the processing of wood, sawdust stands out, originating both in the extraction process and in furniture industries (Tilak et al., 2018; Costa et al., 2022). In a wooden log, only 40 to 60% of its volume is used, and the rest is usually discarded. Of the waste generated, 70% consist of bark and coastal, and the remaining 30% of sawdust (Araujo et al., 2019).

In his research in Brazil, Mwango and Kambole (2019) estimated that a medium-sized sawmill, designed to produce two thousand cubic meters of sawn wood per month, can generate 78 tons of sawdust/month. In total, the country's sawmills would generate around 620 thousand tons per year. The problems caused to the environment are innumerable. One of the main factors is burning, which pollutes the environment by generating carbon dioxide. Another impacting factor is the percentage of waste discarded in the environment, causing soil and water pollution. Therefore, the reuse of wood residues, such as sawdust, is a topic of great technological and environmental importance.

In terms of chemical composition, the sawdust is composed of approximately 60% carbon, 34% oxygen, 5% hydrogen, and 1% nitrogen. The organic polymers, of which it is composed, are essentially cellulose and lignin (Araujo et al., 2019).

Sawdust has been the subject of studies for application on several work fronts. Ischia et al. (2011), in his work, performed the pyrolysis of an organic residue with clay. He explained the reaction between clay and the residue, like sawdust, considering its high loss of mass.

Quesada et al. (2012), Benjeddou and Alyousef (2018), and Cultrone et al. (2020) studied the incorporation of sawdust waste in the production of clay bricks. They concluded that it is possible to add a maximum of 10% sawdust to obtain a resistant brick, under the risk of deformation of the product due to expansion, which was experienced.

Dogamala (2015) and Gil et al. (2017) studied the incorporation of sawdust in mortars and concluded that up to 0.5% could be added to the mass without mechanical strength loss. Ekpunobi et al. (2019) used sawdust with clay to produce water filters and incorporated up to 50% sawdust in a formulation with clay and diatomite. Other reuse alternatives were studied by Pinto et al. (2016), who developed pieces of wood using sawdust mixed with resins, and by Bose and Das (2015), in the production of porous membranes for water filtration.

Mangi et al. (2019) provided a good overview of 17 studies conducted on concrete masonry blocks, between 2012 and 2016, in 11 different countries. This review underscored the potential for increased utilization of sawdust concrete blocks as lightweight masonry units in building.

The alternative proposed in this work for sawdust destination is its incorporation in the LWA manufacture. The LWA can be defined as a set of processed or manufactured natural grains that have different sizes and are interconnected by agglomerating material. Its sintering takes place between 1,100 and 1,350°C, and the raw materials used can be natural, clay, slate, shales, or waste. LWA's most important properties are mechanical strength and bulk density (Mohammed and Hamad, 2014; Angelin et al., 2017).

The LWA has a low apparent density, between 400 and 1200 kg.m^{-3}, and high mechanical resistance to crushing compression of 10 to 40 MPa. It has a multitude of applications, as an element of civil construction with the reduction of the weight of the structure, as a draining floor, an adornment element for gardens, a water filter, among others (Moravia et al., 2006; Santis et al., 2016; Ayati et al., 2019; Souza et al., 2020).

An important characteristic to be observed in the LWA used in concrete is its effective adhesion to the hydrated cement paste, which surrounds it. This adhesion occurs due to the rough texture of the aggregate surface, resulting in a mechanical interlock between the aggregate and the paste (Neville, 1997).

The use of wood wastes has contributed to the rationalization of forest resources, providing a socioeconomic alternative for companies, in addition to contributing to the environmental adequacy of industrial solid waste management. Mineral wastes including excavated clay (Ayati et al., 2019), zeolitic rocks (Volland and Brötz, 2015), municipal solid waste incinerator bottom ash (Cheeseman et al., 2005), have been extensively used to produce building materials including sintered porous products such as the LWA. The abundance of research on the use of waste material in the manufacture of recycled aggregates is due to environmental concerns associated with the extraction of natural aggregates. These include damage to topsoil and natural plant life, pollution of groundwater due to the use of hazardous chemical such as Hg and As. LWA is normally manufactured using a high-temperature firing treatment. This provides an opportunity to employ mineral wastes as raw materials once the process reduces the leachability of problematic constituents through physical encapsulation within a silica/aluminosilicate-based matrix.

The objective of this research was to produce an LWA for different applications, among them, as aggregate for civil construction, bricks, and as an adornment element. For this, the sawdust was tested by comparing its efficiency with other raw materials: diesel fuel oil and mineral coal, already used to reduce the density of the final product (although not considered sustainable materials). A commercial LWA was also acquired, which was characterized for comparison with the aggregate produced in this research.

Materials and Methods

Raw materials

The clay used in this work came from a deposit located in the state of Alagoas, northeastern Brazil. It is called Igreja Nova (IN) because it comes from the municipality of the same name, with geographical coordinates of Latitude 10° 7’ 13” South and Longitude 36° 39’ 39” West. Mineral coal was purchased in the local market.

The sawdust came from a lumber company that produced furniture, floors, and decorative veneers in the city of Estância (SE). The sawdust was of the Timborana type (*Pseudopiptadenia psilostachya*) with an apparent specific mass of 0.90 g.cm^{-3} and high mechanical resistance. The diesel fuel used was Petrobras Grid S-10 brand, purchased locally. The commercial LWA was purchased at CINEXPAN-Brazil, with a diameter of 19 mm.

Preparation of raw materials

A sample of approximately 20 kg of clay was collected directly from the deposit to execute the tests. The samples were homogenized, dried in air and then in an oven at a temperature of 50 ± 10°C for 48 hours, to avoid burning organic matter. In order to start the technological characterization of these materials, their breakdown and granulometric reduction were carried out in a hammer mill, with a 2 mm grid opening. A sample of about 1 kg was separated by quartering and passed through a sieve 80 (0.177 mm) to perform the characterization tests: X-ray diffraction, X-ray fluorescence, particle size analysis, plasticity index, differential thermal analysis, and dilatometric analysis. Another sample, about 2 kg, was collected and passed through a sieve 60 (0.25 mm) to produce specimens.

The sawdust and mineral coal, received in powder form, were dried in an oven at 50±10°C and then passed through a sieve 60 (0.25 mm). The commercial LWA had already been acquired in 19 mm diameter.

Preparation of formulations

The samples in the form of powder were weighed on a precision scale of the Marte brand with a resolution of 0.01 g. They were then humidified at 8% and granulated using a mechanical mixer. To adjust the granulometry, they were passed through a 1.2 mm sieve. Afterward, the formulations were left in closed plastic bags, for 24 hours, to homogenize the moisture.

Initially, specimens were produced using only the IN clay and burned to determine the ideal firing temperature. Twelve cylindrical specimens of each formulation were formed in a of 20 x 20 mm dimension using a manual press with uniaxial compaction pressure of 35 MPa. The specimens were initially dried in open air for 24 hours and then in an oven at 100 ± 5°C until a constant weight was obtained.

The firing step was carried out in a JUNG oven model LF 0612 at temperatures of 900, 1,000, and 1,100°C at a heating rate of 20°C/min with a level of 20 min at the highest temperature, and the firing temperature was based on the result of the differential thermal analysis test. After testing with clay, the ideal firing temperature was set at 1,100°C. Table 1 shows the formulations to produce LWA.

Table 1 – Formulations to produce the lightweight aggregate (%).

Raw material	(%) of each raw material								
	STD	B	C	D	E	F	G	H	I
Lightweight[1] agreggate [1]	100								
IN clay	-	95	90	80	95	90	80	98	95
Coil	-	5	10	20	-	-	-	-	-
Sawdust	-	-	-	-	5	10	20	-	-
Oil	-	-	-	-	-	-	-	2	5

[1]Commercial lightweight aggregate; STD: standard.

The formulations were divided into standard formulations (STD), which refer to a sample of commercial LWA from CINEXPAN-Brazil whose characteristics were determined for comparison with the LWA produced in this research. The formulations from B to D correspond to the variation of coal percentage, from E to G, they correspond to the variation of sawdust percentage, and from H to I, the variation of diesel fuel oil.

Technological tests to characterize raw materials

Particle size distribution

The screening method, followed by sedimentation, was used to determine the size distribution of the clay particles in accordance with NBR 7181 (ABNT, 2016a) and ASTM D422-63 (ASTM, 1998).

Chemical analysis

The percentages of the constituent oxides of the clay and sawdust samples were determined by semi-quantitative measurements using the X-ray fluorescence technique. The measurements were carried out in a vacuum in Bruker brand equipment, model S4 Pioneer, using samples with a mass of around 10 g, pressed in the shape of cylindrical bodies with a diameter of 20 mm and a thickness of approximately 3 mm.

Loss to fire

Determined by the difference in mass, before and after burning at 1,000°C, in an oven with a landing time of 2 hours (ASTM, 1992).

Differential thermal analysis

The thermal events presented by the clay sample in the temperature range between 25 and 1,200°C were recorded in a TA Instruments equipment, model SDT 2960. The samples were measured in a platinum crucible, under synthetic air flow, with a flow rate of 100 ml/min and heating rate of 10°C/min.

Evaluation of plasticity

The liquidity (LL) and plasticity (PL) limits were obtained according to ASTM D4318-7180 (ASTM, 2010a), NBR 6459 (ABNT, 2016b) and NBR 7180 (ABNT, 1984).

The plasticity index (PI) is the result of the arithmetic difference between LL and PL, which can be expressed by Equation 1, where PI is the plasticity index, LL is the liquidity limit and PL is the plasticity limit. The experimental error was approximately ± 3%.

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

Mineralogical analysis

X-ray diffractometry was used to identify the crystalline phases according to the standards obtained in the ICSD (Inorganic Crystal Structure Database) and the analysis was performed using the software Match! in the demo version. The diffraction patterns were obtained in a Rigaku D-MAX 100 equipment, using Cu $K_\alpha 1$ radiation ($\lambda = 1.5418$ Å), in continuous scanning mode, in an angular range from 5 to 70º, and scanning speed of 1º/min. The analysis was performed in two parts: the clay fraction (< 2 μm) was separated by centrifugation, then treated with H_2O_2 for the elimination of organic matter and with HCl for the elimination of carbonates. Accessory minerals were analyzed with the remaining material (Moon et al., 2021).

Dilatometric analysis

Dilatometric measurements were performed to verify the dimensional changes of thermal expansion and retraction involved in the clay densification process. The specimens were prepared by compaction in a cylindrical mold 12 mm in diameter and 6 mm in height, previously calcined at 440°C for 2 hours to eliminate organic matter. For the tests, a Netzsch model DIL 402PC dilatometer was used, with synthetic air flow and flow rate of 100 ml/min, varying from room temperature to 1,200°C with a heating rate of 10°C/min. The ideal firing temperature was obtained from the derivative of the dilatometric curve, corresponding to the maximum retraction temperature (Zaied et al., 2015).

Characterization tests of specimens after burning

Water absorption and mechanical resistance to compression

After burning, the specimens were characterized by means of water absorption (WA) test, with immersion in water for 24 hours, according to the ASTM C-20-2005 standard (ASTM, 2005). The results can be expressed by Equation 2, where m_1 is the dry mass and m_2 the saturated mass:

$$WA = (m_2 - m_1/m_1).100 \tag{2}$$

The apparent specific mass of the sintered bodies was also determined using the Archimedes method.

The compressive rupture stress (CRS) after firing was obtained in an INSTRON tensiometer, model 3385H, with a load application speed of 1 mm/min, using cylindrical specimens. The results can be expressed by Equation 3 where *P* is the load applied in *N*, and *A* is the cross-sectional area (mm²), adapted from ASTM C-1231 (ASTM, 2010b). As the specimens are cylindrical, this method was used even for the commercial LWA, enabling the comparison of results.

$$CRS = P/A \tag{3}$$

Results

Table 2 presents the chemical analysis of the IN clay. The clay is rich in SiO_2, Al_2O_3 and fluxing alkali oxides (K_2O and Fe_2O_3). Additionally, it is noted that the sawdust is rich in calcium and has a high loss on fire, which contributed to the reduction of the LWA density.

According to Cabral et al. (2008), the chemical composition of a clay for the production of LWA must meet the following range: (%) SiO_2 from 50 to 65, (%) Al_2O_3 from 16 to 20, (%) CaO from 1 to 4, (%) Fe_2O_3 from 5 to 9 and (%) MgO from 1.5 to 3.5. The clay serves practically all ranges.

Lo et al. (2016) defined that the degree of vitrification of a clay must be determined by the ratio of SiO_2/Σfluxants (CaO, K_2O, Na_2O, Fe_2O_3, MgO), which must be > 2, to obtain the viscosity of the liquid phase required during the firing process. As observed in Table 2, the clay has a rate of 4.47, enough to form a liquid phase.

About sawdust, it is constituted mainly of SiO_2 and CaO and presents a high mass loss at 1,000°C (21%) necessary to promote the porosity of the LWA (Ferreira et al., 2001).

The granulometric distribution of raw materials is also shown in Table 2. According to Zanelli et al. (2015), the fraction of fines < 2 μm gives a greater specific area, favoring the development of plasticity in clays. Therefore, the clay fraction range < 2 μm (39.7%) favors plasticity, obtaining greater mechanical resistance of bodies conformed to green and, proportionally, improves sintering and mechanical resistance after firing. The organic matter content (1.4%) is considered high for fast-burning cycles, but essencial to produce LWA.

Optimal plasticity is the minimum necessary for the forming process to take place, so as not to cause further problems such as deformations and increase the mechanical resistance of green or dry parts (Maestrelli et al., 2013). The plasticity index can be classified as low when it is less than 7%, medium when results oscillate between 7 and 15%, and high when it is greater than 15% (Domenec and Sanches, 1994).

Table 2 – Chemical and physical analysis (%).

Analysis	Clay	Sawdust	Coal
> 60 (μm)	21.1	0	0
2–60 (μm)	39.2	100	100
< 2 (μm)	39.7	-	-
OM	1.4	-	-
PI	10.0	-	-
Bulk dry ($g.cm^{-3}$)	1.4	0.6	1.1
LOI	5.0	21.5	
SiO_2	63.8	16.9	
Al_2O_3	15.9	2.7	
Cl	0.1	0.2	
CaO	0.7	32.6	
Fe_2O_3	5.2	0.8	
K_2O	4.3	0.2	
Na_2O	1.5	7.0	
MgO	2.6	7.2	
TiO_2	0.8	-	

OM: organic material; PI: Plasticity Index; LOI: loss of mass.

Table 2 also presents the results of physical characterization. The average plasticity index values of the clay were around 10%, considered of medium plasticity. This average value is probably due to the high content of quartz and accessory minerals such as muscovite, identified in the X-ray diffractogram (Figure 1).

In the analysis of X-ray diffraction of the clay, we can mainly observe the illite clay minerals (JCPDS 96900-9666), which provide K_2O and favor sintering during firing. To a lesser extent, it presents the muscovite accessory (JCPDS 96101-1059), which supplies the oxides Na_2O and K_2O, in addition to quartz (JCPDS 96101-1160), which together with the other oxides, form the vitreous phase that fills the pores, giving the mass densification after firing (Zaied et al., 2015).

Figure 2 shows the differential thermal analysis curve of the IN clay. An endothermic peak was observed at about 100°C, due to loss of adsorbed water. It is also common to lose hydroxyls in clays up to 700°C. An endothermic peak was also observed due to the formation of a liquid phase at 1,100°C (Arsenovic et al., 2014).

Figure 3 shows the mechanical strength compression of the IN clay burned at temperatures of 900, 1,000, and 1,100°C, to determine at what temperature, the clay would have the best mechanical resistance. It was observed in the burning at 1,100°C that the resistance of the clay approached the resistance obtained with commercial gravel, which is in a range of 180 to 400 MPa (Bauer, 2019). Thus, to meet the resistance requirement, the formulations were burned at 1,100°C.

Figure 4 shows the unit mass of the formulations as well as the commercial LWA (STD). The LWA has low bulk density, according to the range recommended by Ayati et al. (2019), which has unit mass between 400 and 1200 $kg.m^{-3}$. Thus, all formulations are within the recommended range. It is worth noting that formulation E (with 5% sawdust incorporation) presented the lowest unit mass, even compared to commercial LWA and the other raw materials.

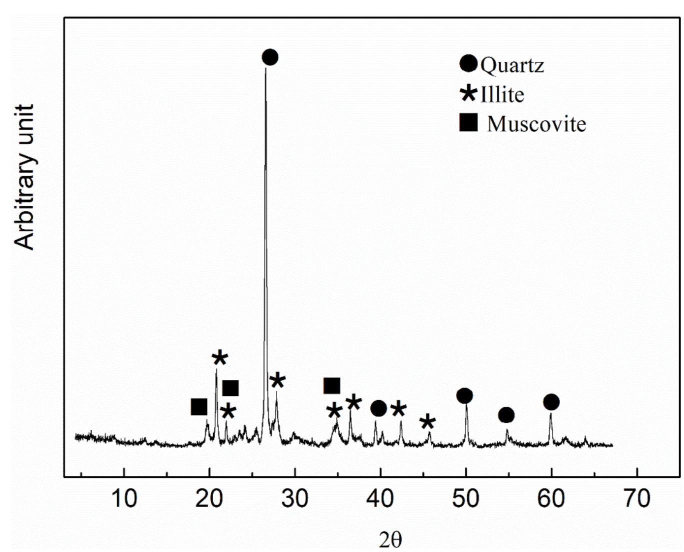

Figure 1 – Diffraction pattern of IN clay and the minerals identified.

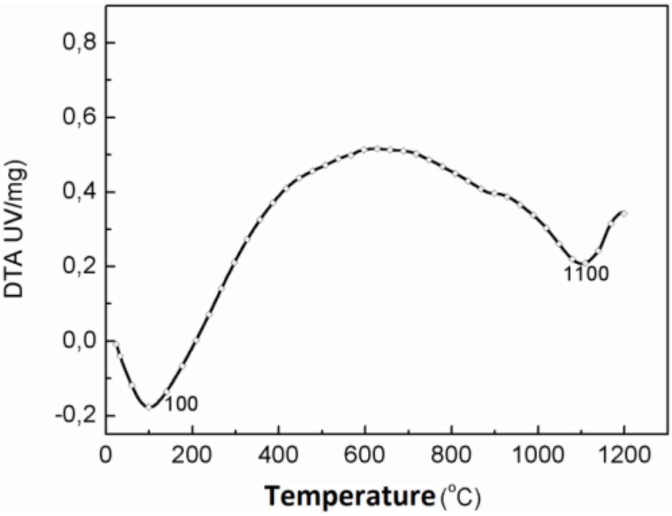

Figure 2 – Differential thermal analysis of IN clay.
DTA: differential thermal analysis.

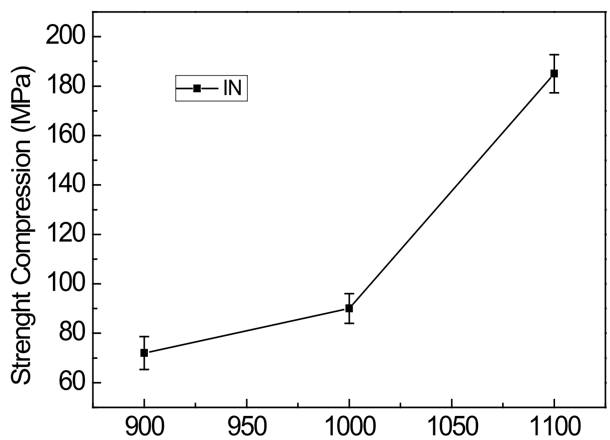

Figure 3 – Strength compressive of IN clay.
IN: Igreja Nova.

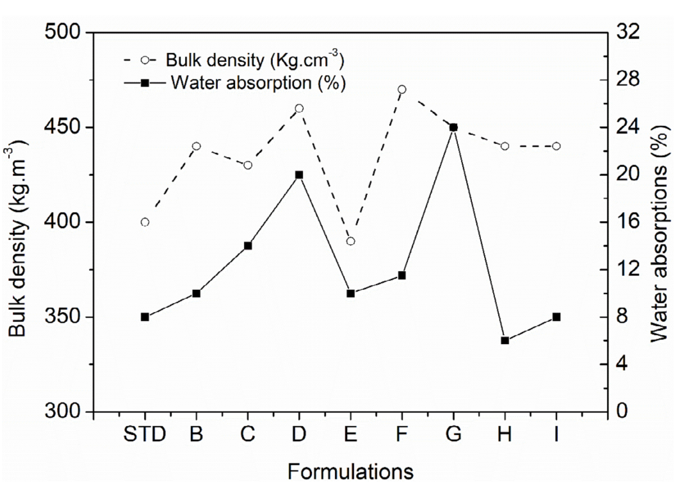

Figure 4 – Water absorption and dry bulk density of the formulations.
STD: standard.

According to Figure 4, as sawdust was added, an increase in water absorption was observed, favored by the loss of mass that occurred due to sawdust dissociation. The same behavior was observed with increasing incorporation of mineral coal and fuel oil. According to Volland and Brötz (2015) and Ayate (2018), the absorption should be less than 20%. As the focus was on sawdust, formulations E (8.5%) and F (10%) showed water absorption within the range and close to the standard (8%).

According to Zaetang et al. (2013) in his studies applying LWA in lightweight concrete, a reduction in density and thermal conductivity was observed (approximately 3–4 times) compared to a concrete with rock. The densities of all LWAs ranged from 558 to 775 kg/m^3 and can be used as a thermal insulation material. The thermal conductivity coefficients of the LWAs were 0.16 and 0.25 W/mK, slightly higher than most.

About water absorption, the values ranged from 8 to 20%, much higher than a conventional gravel that ranges from 3 to 6%. According to Rossignolo and Santis (2013), aggregating with high water absorption favors greater adherence of concrete to the aggregate, which can be observed in SEM images.

According to Figure 5, the mechanical compressive strength of the formulations ranged from (5 to 16 MPa) and was higher than that of the reference commercial LWA (5 MPa). The best result was obtained in formulation E (11.5 MPa) with 5% sawdust and C (16.0 MPa) with 10% coal, surpassing almost all formulations. The results are superior to those found by other authors (Rossignolo, 2009; Tang et al., 2011; Volland and Brötz, 2015; Ayati et al., 2019).

After firing, an X-ray diffractometry test of the LWA of the formulation (E) was carried out and the phases quartz (76%), mullite (21%) and leucite (3.1%) were identified (Oliveira et al., 2019).

The Figure 6 displays a photo of the artificial LWA clay produced. It can be observed the characteristic of swelling and roughness due to the release of the dissociated components.

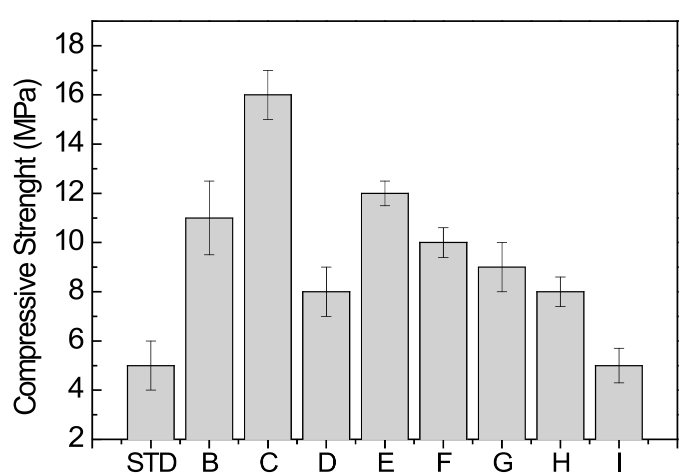

Figure 5 – Strength at compression of formulations studied.

Figure 6 – Photo of the artificial lightweight aggregates clay produced.

Conclusions

Brazil has enormous potential for the LWA use in construction, which can be made from clay, and a product that decomposes after burning and leaves pores to confer density reduction such as plastics, leather, sawdust, and even fuel. The country has large clay reserves to produce this product nationally. The clay used in the manufacture of the LWA researched is rich in illite and, in turn, in fluxing oxides (Na_2O and Fe_2O_3), which favored its sintering at 1,100°C, contributing to obtaining a mechanical compressive strength, after firing, and low density.

The incorporation of sawdust up to 5% was sufficient to obtain a product that meets all the technological properties of a LWA for commercial use.

This research demonstrated the feasibility of incorporating sawdust in the production of high-strength and low-density LWAs, compared to commercial LWA and those produced with non-sustainable materials (mineral coal and fuel oil). Additionally, this work presented an alternative for the disposal of sawdust powder, which reduces the environmental impact, either caused by unnecessary waste or by the extraction of natural resources to produce construction materials.

Considering the general aspects of the literature discussed in this study, it is observed that the waste contributed to the improvement of the properties. Through this work it was possible to verify that the behavior of the LWA is influenced by several factors in its manufacture, mainly regarding the percentage of incorporated residue. There are several types of wood waste, but all of them have organic characteristics and, after burning at 400°C, they have already been eliminated. Therefore, the residue that is often sent to landfills can be a sustainable alternative to its inadequate disposal in landfills and in the environment. However, it is important to worry about the application of waste, requiring more environmental analysis linked to these types of studies. So that the intention of these surveys is truly sustainable and does not potentiate the environmental impacts.

Contribution of authors

OLIVEIRA, H. A.: Methodology; Investigation; Writing – Review & Editing; Conceptualization. SANTOS, C. P.: Methodology; Investigation; Conceptualization. MELO, F. M. C.: Formal Analysis. ALMEIDA, V. G. O.: Formal Analysis; Writing – Review & Editing. MACEDO, Z. S.: Data curation; Validation.

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