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MINING AND CONSTRUCTION WASTE IN THE AMAZON (BRAZIL) AS A BASIS FOR THE PRODUCTION OF ECOLOGICAL BRICKS

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Abstract: The generation of large volumes of tailings from mining projects is a cause for concern, as is the increase in waste from civil construction, both of which have caused various environmental problems in Brazil and around the world. It is therefore necessary to find alternatives for reusing this waste and minimizing the impacts generated by its disposal, which often takes place in inappropriate locations and generates environmental impacts. In the search for an option, this study aims to analyze the quality of soil cement bricks made with different compositional traits, focusing on the use of bauxite tailings and construction waste. The bricks produced were subjected to granulometric analysis, water absorption analysis, preliminary analysis, compressive strength test, abrasion test and dimensional analysis, in order to verify that they are within the parameters established by the standards for the production and use of soil cement bricks. The results showed that the bricks produced from bauxite tailings and construction waste, using different mixtures, meet the physical parameters required by current Brazilian standards, pointing to the reuse of tailings as inputs for construction work.
Keywords: Bauxite tailings; ecological bricks; reuse.

INTRODUCTION

The mining industry is one of Brazil's most important economic activities. The great diversity of natural wealth makes Brazil one of the largest mineral producers in the world, generating thousands of jobs and considerable development. According to data from the Brazilian Mining Institute - IBRAM (2024), the mining sector recorded an 8% increase in turnover to the same period in 2023, totaling R$129.5 billion (excluding oil and gas) and Brazilian mineral exports reached US$21.54 billion, an increase of 8.5%.

Among the minerals with the largest share of the sector's turnover, bauxite stands out, ranking fourth in the mineral sector's turnover in 2024, accounting for around 2% (IBRAM, 2024). Bauxite is the main ore used in the production of aluminum, one of the most widely used metals in modern industry. Brazil has around 3.6 billion tons of ore reserves, 92% of which is metallurgical bauxite, which is used in the production of primary aluminum. The state of Pará holds approximately 75% of Brazil's total reserves (QUARESMA, 2009). One of the major mining projects in the state of Pará is located in the town of Juruti, which has one of the largest deposits of high-quality bauxite in the world, with a potential reserve of around 700 million tons.

Although the mining industry generates several benefits, mainly in the economy, its activities are responsible for producing large volumes of waste during the extraction processes (BRUSCHI, 2020). This waste, which apparently has no economic value, is known as mining waste (GOMES et al., 2017). The improper disposal of these materials can cause serious problems for the environment, such as water and air pollution, as well as posing a potential risk to social security (ARMSTRONG et al., 2019).

Another sector responsible for a large amount of waste is the construction industry. According to Valotto (2007), this waste comes from various construction stages, such as: foundations, masonry, electrical and plumbing installations, internal/external plastering, coatings, among others. These products are one of the biggest generators of waste in the world, as well as the lack of proper management and final disposal, resulting in various environmental problems.

According to Pinto (2015), recycling and reusing waste is fundamental to sustainable development. Soil-cement bricks fit into this concept because they can be made from various types of waste. In addition to reducing the volume of waste discarded in nature, the process of making ecological bricks supports sustainability, as there is no burning as in conventional bricks, the equipment used is simple and can be carried out without the need for specialized labor, in addition to reducing construction costs, execution time and better thermal and acoustic insulation (PINTO, 2015).

In this way, this work aims to contribute, through the incorporation of bauxite tailings and construction waste, with the production of ecological bricks, to a better use and proper disposal of these resources, providing lower socio-environmental impacts and breaking paradigms on the subject.

MATERIALS AND METHODS

SELECTING AND COLLECTING THE MATERIALS USED TO MAKE THE BRICKS

The bauxite tailings (RB) samples were donated by Alcoa, a company operating in the municipality of Juruti (Pará). The civil construction waste (CCW) samples were collected at the Federal University of Western Pará (UFOPA) - Juruti Campus (CJur); the soil was obtained from the UFOPA - CJur site.

MAKING SOIL/CEMENT AND CEMENT/RB/RCC BRICKS

All the methodological procedures were carried out in the laboratories and on the premises of UFOPA - Juruti Campus (CJur). The bricks were manufactured in accordance with NBR 10833, which deals with the manufacture of bricks and soil-cement blocks using a manual or hydraulic press. The brick manufacturing process used the ECOMÁQUINAS model hydraulic press (Fig. 1), in the soil and rock mechanics laboratory at UFOPA - Juruti Campus.

Figure 1 - Hydraulic press used to produce the bricks. Source: Author's archive (2024).

The bricks in Batch I (6:1 ratio) were produced from soil and cement inputs. The bricks produced from RB, RCC and cement inputs (Lots II/ 6:1:1; Lot III/ 5:2:1) underwent treatment/selection to remove materials that would not be beneficial for making the bricks (e.g. wood scraps, nails or wires, Styrofoam).

The production process was similar for the three batches, respecting their proportions. The inputs were mixed manually with a hoe until they became a homogeneous mixture. Afterwards, water was gradually added to the mixture until it reached the ideal humidity point and then placed in the hydraulic press for compacting and shaping the bricks. After manufacture, the bricks underwent a curing period, being moistened for 7 days after manufacture.

DIMENSIONAL, PHYSICAL RESISTANCE AND WATER ABSORPTION TESTS

After the bricks had been made for 14 days, they were subjected to particle size analysis, water absorption, dimensional analysis, preliminary physical resistance analysis, abrasion test and compressive strength test, to confirm that they met the parameters of standards NBR 8491 (Soil cement bricks - Requirements) and NBR 8492 (Solid soil cement bricks - Determination of compressive strength and water absorption) and can be used as a means of comparison with bricks made from bauxite tailings and civil construction.

Particle size analysis

The granulometric tests were carried out at UFOPA's Ore Treatment Laboratory (LTM) - CJur. The granulometry was evaluated for the soil, the construction waste and the bauxite waste, based on the methodology described in ABNT NBR 7181 Soil - Granulometric Analysis.

Sieves with meshes of 4.76 mm, 2.38 mm, 1.41 mm, 0.6 mm, 0.3 mm, 0.15 mm and 0.074 mm were used, stacked in that order, and placed in the MATEST vibrating sieve for 10 min/sample. Figure 2A-C shows the organization of the soil, RCC and RB samples, respectively. The samples were dried at room temperature and about 1 kg of each sample was weighed and sieved (Fig.3A - C).

Water absorption analysis

The water absorption tests were carried out at the Natural Products Laboratory (LPN) at UFOPA - CJur, based on the methodology described in ABNT standard NBR 8492 - Solid soil-cement brick: determination of compressive strength and water absorption.

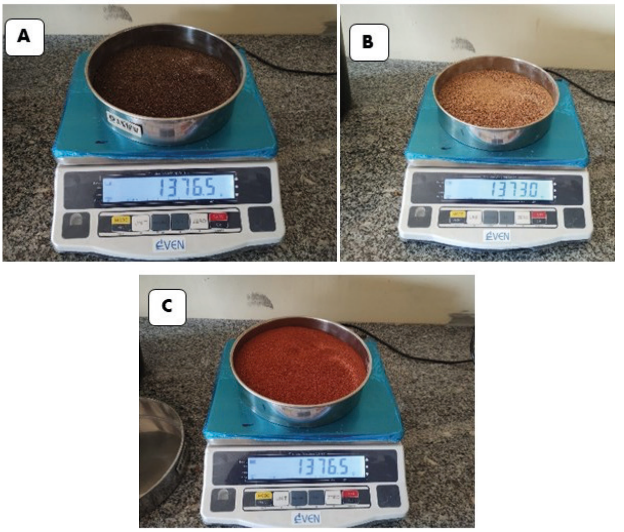


Figure 2 - (A) Photograph of soil samples, (B) construction tailings and (C) bauxite tailings. Source: Author's archive (2024).

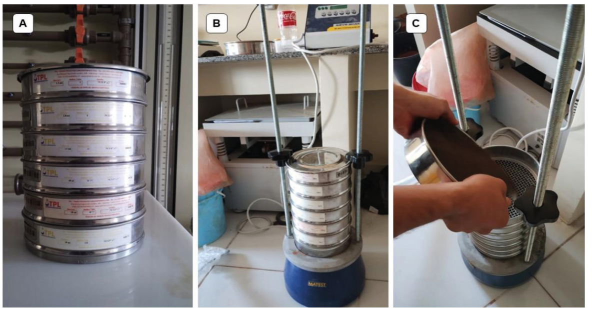


Figure 3 - (A) Sieve system used, (B) organized on the mechanical sifter, and (C) sample sieving process. Source: Author's archive (2024).

An analytical balance with a sensitivity of 1g and a capacity of 10 kg was used to weigh each sample. We also used a drying oven with the capacity to maintain the temperature between 105°C and 110°C, three 12-liter glass desiccators, a container (basin) with water to submerge the bricks, and a damp cloth. After the analysis, all the bricks were stored in Block B of the UFOPA - Juruti Campus building, where they were manufactured.

The selected bricks were placed in a Seriels Vulcan Bacteriological Culture FCC-5000 drying oven for a period of 24 hours. They were then placed in a dissector to preserve the humidity until they reached room temperature.

When they reached room temperature, the bricks were weighed and the values entered into a spreadsheet. If there was any loss of mass, the bricks were returned to the oven to repeat the cycle until they reached the mass constant, i.e. the masses of the bricks did not vary from one day to the next, thus obtaining the dry weight (M1). After reaching the mass constant, the bricks were submerged in a container of water for 24 hours. After 24 hours, the bricks were removed from the container of water and, using a damp cloth, the excess water was removed for less than 1 minute, after which they were weighed to obtain the weight of the saturated brick (M2).

Dimensional analysis

The dimensional analysis tests were carried out at LTM-CJur. The analysis was used for all the bricks in each batch, based on the methodology described in the ABNT NBR 8491 standard - Soil cement bricks: Requirements.

To carry out the tests, a ruler measuring 30 centimeters was used to measure the length, width, height, distance between holes and wall thickness.

The dimensional parameters established by NBR 8491 (Soil cement bricks - Requirements) were applied to the ecological brick tests. The nominal dimensions of the bricks must meet the parameters set out in Table 4 for length (C), width (L) and height (H), although they can have different dimensions to those set out in the table as long as the height (H) of the brick remains less than its width (L). As the bricks are of the hollow type, i.e. they have two holes, two other dimensional parameters must be considered, which are the minimum distance between the holes (d) and the minimum wall thickness (e) (Fig. 4A and B).

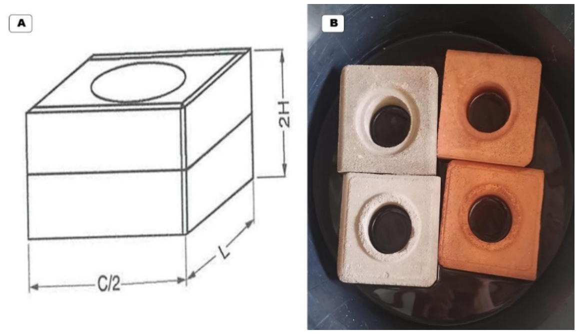


Figure 4 - (A) Illustration and (B) image of the specimens cut in half. Source: Author's archive (2024).

Preliminary resistance analysis

The test consisted of applying manual force with the thumbs to both ends of the brick, gradually and in a vertical downward direction. If there is any sign of rupture or cracking, the strength of the brick is considered inadequate and the brick must be discarded. However, if there is no sign of damage to the brick, its strength is adequate to continue with the tests, which is an indication that the bricks may be able to pass the compressive strength test.

Compressive strength test

The test was carried out at LTM - UFOPA - CJur, using a FORTEST manual hydraulic concrete press, with a digital indicator with a scale equal to 100.00tf (one hundred tons force) and a capacity of 100 tons, where three bricks from each batch were analyzed. The methodology described in ABNT standard NBR 8492 - Solid soil-cement brick: determination of compressive strength and water absorption was adopted. In addition to the hydraulic press, two steel plates measuring 12.5 cm x 25 cm and 1 cm thick were used in the test as a contact surface for the homogeneous distribution of the force applied by the press to the bricks, Portland CP-II cement for making the cement paste, and a container with water to submerge the bricks.

Nine bricks were cut in half and a cement paste in a ratio of 2:1 (cement: water) was applied to the faces of the two halves of the bricks, joining the cut surfaces in an inverted manner, with a layer approximately 3mm thick, as shown in Figures 5A and B. The cement paste was also applied to the lower and upper faces of the specimens (Fig. 5C).

After hardening the material applied to the samples, they were submerged in a container of water where they remained for approximately 6 hours. After this period, they were placed directly in the center of the bottom plate of the testing machine, for the gradual application of the load until the specimens broke.

Figure 5 - (A) Manufactured cement paste, (B) application to the specimens and (C) the finished and identified specimens. Source: Author's archive, 2024.

Abrasion test

To carry out the abrasion test, one brick was selected from each batch. The brick was then cut crosswise, leaving its internal surfaces exposed, and these surfaces were subjected to contact and friction with a steel brush in order to observe the resistance of the internal structure of the bricks.

RESULTS

PARTICLE SIZE ANALYSIS

Table 1 summarizes the information on the amount of soil, construction waste and bauxite tailings retained on each sieve after the particle size analysis.

Sieves	Retained soil mass (g)	Retained mass of RCC (g)	Retained mass of bauxite tailings (g)
4.76 mm	0	0	0
2.38 mm	0	0	0
1.41 mm	27	179,5	115,5
0.6 mm	309,5	348,5	311,5
0.3 mm	487,5	217,0	322,0
0.15 mm	128	118,5	188,5
0.074 mm	48	136,5	62,5

Table 1 - Samples of soil, RCC and bauxite tailings retained on the sieves. Source: Prepared by the author, 2024.

BRICK MANUFACTURING PERIOD

The bricks in the first batch (Batch I) were made using soil and CP-II Portland cement as the manufacturing input, using a 6:1 ratio (Fig. 6). After manufacturing, the bricks began the curing process, humidifying the batch in the 7 days following its manufacture and leaving them to rest for the same amount of time.

The second batch of bricks was made using bauxite tailings, construction waste and CP-II Portland cement, using a ratio of 6:1:1, respectively (Fig. 6B). The curing process followed the same procedures adopted for the first batch.

The third batch of bricks was also made using bauxite tailings, construction waste and CP-II Portland cement, but using a mixing ratio of 5:2:1, respectively (Fig. 6C), and went through the curing process.

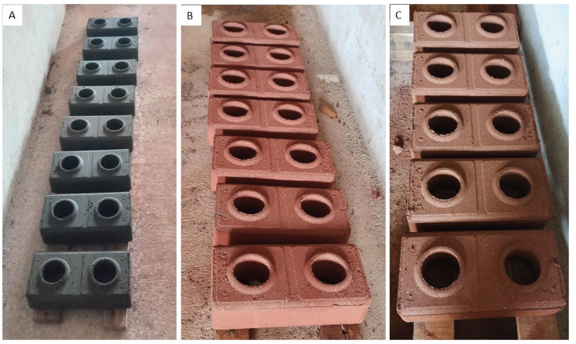


Figure 6 - (A) Bricks produced from Batch I, (B) II and (C) III. Source: Author's archive (2024).

Day	Brick Mass I	Brick Mass II	Brick Mass III
21/06/2023	2988,5g	2773,0g	2720,5g
22/06/2023	2986,5g	2772,0g	2718,0g
23/06/2023	2986,0g	2771,5g	2717,5g
24/06/2023	2986,0g	2771,0g	2717,0g
25/06/2023	2986,0g	2771,0g	2717,0g
26/06/2023	2986,0g	2771,0g	2717,0g
27/06/2023	2986,0g	2771,0g	2717,0g

Table 2 - Mass constant of soil-cement bricks from Batch I. Source: Prepared by the author (2024).

WATER ABSORPTION ANALYSIS

Table 2 shows a summary of the drying procedure for the soil-cement bricks from Batch I, and the masses obtained during each drying process for each brick, until the mass constant was reached. The same procedure was reproduced for the bricks from Batch II and Batch III.

Table 3 summarizes the dry weights (M1) of the three bricks from each batch after drying in the oven, and Table 4 shows the summary of the masses obtained from the saturated bricks (M2) after being submerged in water for 24 hours.

Therefore, with the values obtained, it was possible to carry out the necessary calculations to determine the water absorption of the soil-cement bricks.

Using the following formula:

$A = (M2 - M1) * M1 * 100$

Where:

A = water absorption (%)

M1 = weight of kiln-dried brick (g)

M2 = weight of saturated brick (g)

After performing the calculations, we obtained the water absorption value for the bricks that were subjected to the test. The values are shown in Table 4.

Lots	Brick I (M_1)	Brick II (M_1)	Brick III (M_1)
Lot I	2986,0 g	2771,0 g	2717,0 g
Lot II	2132,5 g	2180,5 g	2330,5 g
Lot III	1973,0 g	2126,0 g	2229,0 g

Table 3 - Dry weights (M1) of bricks after kiln drying. Source: Prepared by the author (2024).

Lots	Brick I (M_2)	Brick II (M_2)	Brick III (M_2)
Lot I	3397,0g	3142,5g	3089,5g
Lot II	2417,0g	2474,0g	2648,0g
Lot III	2264,0g	2441,0g	2560,5g

Table 4 - Masses (M_2) of soil-cement bricks after 24 hours submerged in water. Source: Prepared by the author (2024).

The bricks from batches I and II showed excellent resistance, with no damage or breakage. The bricks from batch III also showed good results, with only brick IV showing a fracture during the test. Tables S1-3 (Supplementary material) show the results obtained for each brick after analysis.

After compression, the moment of rupture values of the specimens were obtained using the digital indicator of the hydraulic press. For values expressed in Mpa (megapascals) and to check that the bricks meet the requirements of Standard 8491, it was necessary to divide the force value obtained from the press indicator by the area of the specimen's contact surface, according to the equation below: $ft = FS$

Where:

Ft is the simple compressive strength, expressed in megapascals (Mpa);

F is the breaking load of the specimen, expressed in newtons (N);

S is the area of load application, expressed in square millimeters (mm²).

To carry out the calculations, the values expressed in tons of force (tf) by the press indicator were transformed into newtons (N). The area of load application was obtained by multiplying the width by the length of the specimens, thus obtaining the area expressed in mm² (Table 5).

Abrasion tests were carried out on one brick from each batch. All of them showed good internal resistance when rubbed with the steel brush, with surfaces that were not very crumbly.

Dimensional analyses of the 13 bricks from each batch were also carried out using a ruler (Tables 5-7, Supplementary material).

Simple compressive strength (Mpa)				
Lots	**Specimen (A)**	**Specimen (B)**	**Specimen (C)**	**Average**
Lot I	2,08	2,13	1,96	2,06
Lot II	1,82	2,66	2,15	2,21
Lot III	1,87	2,39	1,89	2,05

Table 5 - Simple compressive strength of the specimens (MPa). Source: Author's archive (2024).

DISCUSSIONS

Graph 1 shows the particle size curves generated from the data obtained from the three batches of bricks studied by the diameter of the grains of the samples used to make soil cement bricks from batches I, II and III and the percentage of material passing through the 4 to 200 mesh sieve.

It can be seen that the curve of the plotted points for the soil occurs between the #14 and #100 sieves, with the largest range of grain size being between #28 and #48 with 48.75%. For the RCC samples, the particle size curve is steeper between the #14 and #28 sieves, and for the bauxite tailings it is between the #28 and #48 sieves, with 32.2% of the grains.

Therefore, it is interpreted that no amount of material was retained on the #4 and #8 sieves, indicating that there is no boulder present in the samples. Furthermore, all three samples retain material from the #14 sieve onwards. For the soil and bauxite tailings samples, the particle size range is between the #28 and #48 sieves, while the RCC sample is between the #14 and #28 sieves.

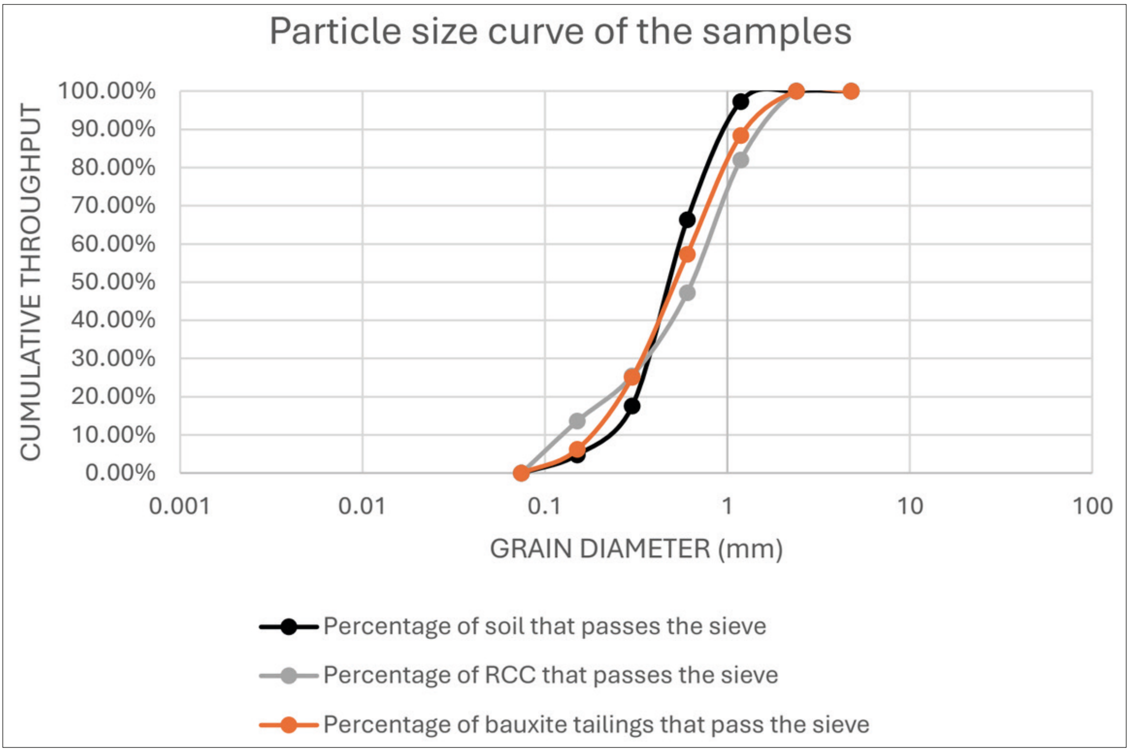
The three samples showed characteristics that indicate a sandy fraction above 50% and, according to Silva et al. (2008), the soil samples used in the bricks must have sandy characteristics above 50% to meet the minimum granulometry requirements, compatible with the results obtained in this work.

Rocha (2023) analyzed the particle size distribution of bauxite tailings from Juruti - Pará, and the samples have similar results to those obtained in this study, confirming that bauxite tailings from Juruti meet the minimum particle size requirements to be used as an input in the manufacture of soil cement bricks.

Due to the local equatorial climate, where temperatures fluctuate between 35ºC and 20ºC between summer and winter in the Amazon according to data from the Center for Weather Forecasting and Climate Studies (CPTEC), the bricks from the three batches were made at different times of the year in order to observe the behavior and performance of the material.

The bricks in batch I and batch III were made during the Amazon winter (December - May), and batch II during the Amazon summer (June - November).

According to the NBR 8491 standard, soil-cement bricks must have average values ≤ 20% and individual values ≤ 22% for water absorption. Table S4 (Supplementary material) summarizes the water absorption data for the bricks produced. The bricks from batch I had average water absorption values of 13.62%, while the bricks from batch III had average values of 14.80% and those from bat-



Graph 1 - Sample particle size curve. Source: Prepared by the author (2024).

ch II 13.47%. According to Grande (2003) and Lima (2010), this difference influences the mechanical strength of the bricks. Preliminary strength tests showed excellent results in terms of mechanical strength for bricks from batches I and II, with no fractures or structural damage, while batch III was more susceptible to fracture.

According to Lima (2010), water absorption values are related to the degree of porosity of the material, so that lower water absorption values indicate less porosity and, consequently, are more resistant. Also according to the author's study, the soil-cement material with the lowest water absorption (close to 15%) was the one with the best results in the compressive strength tests, with values considerably above those required by the standard. This indicates that the bricks from the three batches produced in this study also have good mechanical resistance, as proven by the preliminary analysis and abrasion tests.

The abrasion test is a simple technique for checking the internal strength of soil-cement bricks. The three bricks, each corresponding to a batch manufactured, were cut crosswise and their exposed surface was rubbed with a steel brush. According to Cabello (2011), the smaller the amount of fines generated during the abrasion test, the better the material. Therefore, as the bricks did not crumble easily when rubbed, generating very little fines, the three batches manufactured can be considered to have good internal resistance.

The results obtained in this work are also in line with the study carried out by Grande (2003), who in his study obtained average values of 13% water absorption and found a proportional relationship between the reduction in water absorption and the gain in mechanical strength.

With regard to the dimensional analysis, the 13 bricks in each batch were produced in order to meet the dimensional parameters required by NBR 8491. Although they underwent the curing process in a place free from rain and sun, they were exposed to winter and summer temperature differences, and all the bricks maintained the dimensional standard and met the discrepancy tolerance of ± 3 mm.

In the study by Rocha (2023), the ecological bricks produced from bauxite tailings were similar in size to the results obtained in the analysis of the 3 batches made with soil, construction waste and bauxite tailings in this study. In the research carried out by Lima (2010), the bricks produced with different proportions of soil and granite waste were also similar in size to those in this study.

However, after carrying out the preliminary physical strength analysis test, it was found that the bricks from the three batches produced in this work had good mechanical strength, with 38 of the 39 bricks manufactured showing no fractures or damage when exposed to the test, indicating that they passed the compressive strength test. According to Lima (2010), mechanical strength is linked to the degree of porosity and, as seen above, the bricks had a low degree of porosity, resulting in good compaction of the grains and, consequently, increasing mechanical strength

According to Grande (2003), the proportional relationship between the gain in mechanical strength and the reduction in water absorption in soil-cement mixtures is proven by analyzing the influence of the specific mass of the compacted mixture. This relationship is observed through the cement content added to the soil-cement mixture, which results in lower water absorption and an increase in compressive strength.

According to the NBR 8491 standard, soil-cement bricks must have individual strength values ≥ 1.7 Mpa and average values ≥ 2.0 Mpa. After carrying out the simple compression test, as shown in Table S5 (Supplementary Material), it was found that the bricks from the three batches manufactured meet the requirements of the ABNT standard in terms of the values required for mechanical strength.

The results of the compression test are also in line with the results obtained in the preliminary physical strength analysis, with bricks from batch II having the highest mechanical strength, with an average value of 2.21 Mpa, while bricks from batch III had lower values, with an average of 2.05 Mpa.

With regard to the difference in the inputs used to make the bricks, batches I and III behaved similarly, as they both had similar mechanical strengths (average of 2.06 Mpa and 2.05 Mpa, respectively) and the highest water absorption values (average of 13.62% and 14.80%, respectively). And the bricks from batch II showed the best results in terms of physical and mechanical parameters (average strength of 2.21 Mpa), proving that bauxite tailings and construction waste can be reused if incorporated into structural building elements, as in the case of ecological bricks.

Therefore, based on the results obtained from the physical analysis of the three batches of bricks manufactured, it can be confirmed that the bricks made using soil, construction waste and bauxite waste as inputs meet the current Brazilian standards for making soil-cement bricks, proving that bauxite waste and construction waste can be used as inputs in the production of soil-cement bricks in construction work.

CONCLUSIONS

Based on the studies carried out for this work, it was concluded that:

The three materials used as inputs for the production of ecological bricks (soil, construction waste and bauxite waste) showed favorable characteristics for application in the soil-cement mixture. This can be seen from the particle size analysis of the three samples collected.

Despite the different range of water absorption, it was found that the quality of the bricks is independent of the humidity of the climate, which is advantageous for the manufacture of bricks.

The water absorption analysis showed that the bricks in batches I, II and III meet the standards required by NBR 8491.

The bricks from the three batches showed good mechanical resistance, which was proven by the results obtained from the compression test, which met the standards required by NBR 8491.

The 13 bricks from each batch were produced in order to meet the dimensional parameters required by NBR 8491, and the bricks developed in this study met the required dimensional parameters and the discrepancy tolerance of ± 3 mm.

Based on the results obtained from the performance analysis of the bricks made, the ability to use construction waste and bauxite tailings in soil cement bricks was proven, opening up new possibilities for the sustainable disposal of this waste.

REFERENCES

ARMSTRONG, M. et al. Accounting for tailings dam failures in the valuation of mining projects. **Resources Policy**, [s. l.], v. 63, n. May, p. 101461, 2019.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 8491**: tijolo de solo cimento – requisitos. Rio de Janeiro: ABNT, 2012.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 8492: **Tijolo maciço de solo cimento – análise dimensional – determinação da resistência à compressão e da absorção de água – Método de ensaio.** Rio de Janeiro: ABNT, 1984.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 8492:** tijolo de solo cimento: análise dimensional, determinação da resistência à compressão e da absorção de água: método de ensaio. Rio de Janeiro: ABNT, 2012.

BRUSCHI, G. J. **Estabilização de rejeitos de mineração de bauxita por meio de um sistema ligante álcali-ativado de cinza do bagaço de cana-de-açúcar e cal de carbureto.** 184 f. Dissertação (Mestrado em Engenharia) - Universidade Federal do Rio Grande do Sul, Escola de Engenharia, Programa de Pós-Graduação em Engenharia Civil, Porto Alegre, 2020.

CABELLO, M. L. R. **Reciclagem de resíduo gerado na extração de quartzito.** Tese (Doutorado em Engenharia Metalúrgica, Materiais e de Minas). Universidade Federal de Minas Gerais, Belo Horizonte. 2011.

GRANDE, F. M. **Fabricação de tijolos modulares de solo-cimento por prensagem manual com e sem adição de sílica ativa.** Dissertação (Mestrado) – Escola de Engenharia de São Carlos, Universidade de São Paulo. São Carlos, 2003.

GOMES, L. E. de O. et al. The impacts of the Samarco mine tailing spill on the Rio Doce estuary, Eastern Brazil. **Marine Pollution Bulletin**, [s. l.], v. 120, n. 12, p. 2836, 2017.

INSTITUTO BRASILEIRO DE MINERAÇÃO. **Dados econômicos trimestrais.** [S.I.]: IBRAM, Disponível em: https://ibram.org.br/wp-content/uploads/2024/07/Mineracao-em-Numeros-1S24.pdf.

LIMA, R. C. O. **Estudo da durabilidade de paredes monolíticas e tijolos de solo-cimento incorporados com resíduo de granito.** Dissertação (Mestrado em Engenharia Civil e Ambiental) – Universidade Federal de Campina Grande. Campina Grande, 2010.

PINTO, L. M. **Estudo de tijolos de solo cimento com adição de resíduo de construção civil**. 59 f. Trabalho de Conclusão de Curso (Graduação em Engenheiro Civil) – Universidade Federal de Santa Maria, Centro de Tecnologia, Departamento de Estruturas e Construção Civil, Santa Maria, 2015.

QUARESMA, L. F. **Perfil da Mineração de Bauxita.** Minas Gerais: MME, 2009.

ROCHA, F.S. **Análise das propriedades físicas do rejeito de bauxita como insumo para fabricação de tijolos solo cimento.** Trabalho de Conclusão de Curso (Graduação em Engenharia de Minas) – Universidade Federal do Oeste do Pará. Juruti, 2023.

SILVA, E. P., J. NASCIMENTO, W. B.; BARBOSA, N. P.; LEAL A. F., **Avaliação de painéis de tijolos prensados de solo-cimento incorporados com resíduos de calçados (EVA)**. In: Revista Eletrônica de Materiais e Processos, v.3.2. p. 44-49, 2008.

VALOTTO, D. V. **Busca de informação: gerenciamento de resíduos da construção civil em canteiro de obras.** Monografia. Universidade Estadual de Londrina, 2007.

SUPPLEMENTARY MATERIAL

Bricks	Length (mm)	Width (mm)	Height (mm)	Distance between holes (mm)	Wall thickness (mm)
Brick I					
Brick II					
Brick III					
Brick IV					
Brick V					
Brick VI					
Brick VII	247	125	65	65	32
Brick VIII					
Brick IX					
Brick X					
Brick XI					
Brick XII					
Brick XIII					

Table S1 - Results of the dimensional analysis of the bricks in batch I. Source: Prepared by the author (2024).

Bricks	Length (mm)	Width (mm)	Height (mm)	Distance between holes (mm)	Wall thickness (mm)
Brick I					
Brick II					
Brick III					
Brick IV					
Brick V					
Brick VI					
Brick VII	247	125	66	65	32
Brick VIII					
Brick IX					
Brick X					
Brick XI					
Brick XII					
Brick XIII					

Table S2 - Results of the dimensional analysis of the bricks in batch II. Source: Prepared by the author (2024).

Bricks	Length (mm)	Width (mm)	Height (mm)	Distance between holes (mm)	Wall thickness (mm)
Brick I	247	125	63	65	32
Brick II					
Brick III					
Brick IV					
Brick V					
Brick VI					
Brick VII					
Brick VIII					
Brick IX					
Brick X					
Brick XI					
Brick XII					
Brick XIII					

Table S3 - Results of dimensional analysis of bricks from batch III. Source: Prepared by the author (2024).

Water absorption analysis (%)				
Lots	**Brick I**	**Brick II**	**Brick III**	**Average**
Lot I	13,76%	13,40%	13,70%	13,62%
Lot II	13,34%	13,46%	13,62%	13,47%
Lot III	14,74%	14,81%	14,87%	14,80%

Table S4 - Results of the water absorption analysis of soil-cement bricks. Source: Prepared by the author (2024).

Preliminary Resistance Analysis			
Bricks	**Lot I**	**Lot II**	**Lot III**
Brick I	Ok	Ok	Ok
Brick II	Ok	Ok	Ok
Brick III	Ok	Ok	Ok
Brick IV	Ok	Ok	Not approved
Brick V	Ok	Ok	Ok
Brick VI	Ok	Ok	Ok
Brick VII	Ok	Ok	Ok
Brick VIII	Ok	Ok	Ok
Brick IX	Ok	Ok	Ok
Brick X	Ok	Ok	Ok
Brick XI	Ok	Ok	Ok
Brick XII	Ok	Ok	Ok
Brick XIII	Ok	Ok	Ok

Table S5 - Results of the preliminary physical endurance analysis. Prepared by the author (2024).