# CHARACTERIZATION AND PERFORMANCE OF SOIL-CEMENT BRICKS PRODUCED WITH SOILS FROM THE ARARIPINA REGION (PE)

# CARACTERIZAÇÃO E DESEMPENHO DE TIJOLOS SOLO CIMENTO PRODUZIDOS COM SOLOS DA REGIÃO DE ARARIPINA (PE)

# CARACTERIZACIÓN Y DESEMPEÑO DE LADRILLOS DE SUELO- CEMENTO PRODUCIDOS CON SUELOS DE LA REGIÓN DE ARARIPINA (PE)

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## ABSTRACT

The Araripe region in the state of Pernambuco is home to vast clay mineral reserves overlapping gypsum deposits. They have been considered waste, therefore, disposed of without any exploitation, which could lead to environmental threats. Taking into consideration the need for sustainable materials in the construction field, this study has assessed the technical viability of bricks manufacturing using soil cement from Araripina's horizons A, B, and C - with and without adding crushed-stone dust. After running tests of physical characterization, granulometry and consistency, the results showed a predominance fraction of sand and lack of clay in relation to ABNT NBR 10833/2012, besides revealing fissuration after retraction tests. Bricks molded into traces 1:6 and 1:6:0,25 were submitted to both mechanical and absorption tests. The ones molded into 1:6:0,25 traces revealed a better performance, showing technical viability through adequate stabilization.

**Keywords:** Soil-Cement Bricks. Crushed Stone Dust Waste. Sustainable Construction.

## RESUMO

A região do Araripe (PE) possui extensas reservas de argilominerais sobrepostas às jazidas de gipsita, atualmente tratadas como rejeitos e acumuladas sem aproveitamento, o que pode gerar impactos ambientais. Considerando a necessidade de materiais mais sustentáveis na construção civil, este estudo avaliou a viabilidade técnica da produção de tijolos de solo-cimento com solos dos horizontes A, B e C de Araripina (PE), com e sem adição de pó de brita. Foram realizados ensaios de caracterização física, granulométrica e de consistência. Os resultados indicaram predominância de fração arenosa e déficit de argila em relação à ABNT NBR 10833/2012, além de fissuração no ensaio de retração. Tijolos moldados nos traços 1:6 e 1:6:0,25 foram submetidos a ensaios mecânicos e de absorção. O traço 1:6:0,25 apresentou melhor desempenho, atendendo às exigências das NBR 8497/2012 e 8491/2012, demonstrando viabilidade técnica mediante estabilização adequada.

**Palavras-chave:** Tijolos de Solo-Cimento. Resíduos Pó de Brita. Construção Sustentável.

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# RESUMEN

La región de Araripe (PE) posee extensas reservas de argilominerales superpuestas a los yacimientos de gipsita, actualmente tratadas como residuos y acumuladas sin aprovechamiento, lo que puede generar impactos ambientales. Considerando la necesidad de materiales más sostenibles en la construcción civil, este estudio evaluó la viabilidad técnica de la producción de ladrillos de suelo-cemento con suelos de los horizontes A, B y C de Araripina (PE), con y sin adición de polvo de piedra triturada. Se realizaron estudios de caracterización física, granulométrica y de consistencia. Los resultados indicaron predominancia de la fracción arenosa y déficit de arcilla en relación con la norma ABNT NBR 10833/2012, además de agrietamiento en el ensayo de retracción. Los ladrillos moldeados con dosificaciones 1:6 y 1:6:0,25 fueron sometidos a ensayos mecánicos y de absorción. La dosificación 1:6:0,25 presentó mejor desempeño, cumpliendo los requisitos de las normas NBR 8497/2012 y 8491/2012, lo que demuestra la viabilidad técnica del material mediante una estabilización adecuada.

**Palabras clave:** Ladrillos de Suelo-Cemento. Residuos de Polvo de Piedra Triturada. Construcción Sostenible.

## 1 INTRODUCTION

According to Bezerra (2009), in gypsum mining in the Araripe gypsum pole, there is a need to remove the surface clay capping, which is revealed as the main environmental problem and which covers the mineral layer, being an economic conditioning factor in the feasibility of the type of mining used in the region, which has been stored for later backfill in the recovery phase of the mined area. Considering the maximum limit of the overburden/ore ratio up to 1:1. The volume of waste generated represents an environmental cost for society and a financial cost for the miner.

For this reason, in the Araripe Gypsum Pole, where the magnitude of the problem is increased by the tonnage produced and the years of mining activity, some studies have been carried out with a view to taking advantage of this capping, which remains, however, unapplied. The technological routes pursued are directed by the mineralogical, chemical and physical characteristics of the capping clays.

The civil construction sector stands out as one of the sectors that most consumes natural resources and generates waste. Given this scenario, the industry has intensified the adoption of innovative practices aimed at incorporating sustainability into its production chain (Vilela et al., 2020). Among the most relevant advances is the use of materials with less environmental impact, such as soil-cement bricks, which are presented as an economically viable and environmentally more appropriate alternative in relation to traditional masonry systems. One notable advancement is the use of eco-friendly materials, such as soil-cement bricks, which offer a cost-effective and environmentally conscious alternative to conventional masonry materials. These bricks can be produced on-site using locally sourced materials, thereby reducing transportation demands and associated energy consumption (Silva et al, 2024).

## 2 THEORETICAL FRAMEWORK

### 2.1 SOLO

According to Silva (2005), soil consists of an unconsolidated material present in the surface layer of the Earth, being composed of several minerals, classically defined as a set of mineral particles arising from the weathering of the mother rock. This material has voids filled by fluids (water and/or air) and can be classified as residual soil.

### 2.1.1 Soil Properties

Soil, as an engineering material and natural substrate, has a behavior that is intrinsically determined by the nature of its primary constituents. As Chiossi (2015) postulates, two physical attributes are crucial for predicting the behavior of soils: particle size (particle size) and grain morphology (particle shape). The interdependence of these factors not only establishes the formal classification of soil, but also governs its characteristics of permeability, strength, and plasticity.

Particle size represents the distribution of soil particle diameters and is the first key to their categorization. ABNT, through NBR 6502/1995, establishes a hierarchy of classes in descending order of size: boulders, sands, silts and clays. This differentiation is key, as the size of the particles determines the specific surface area of the soil, the ratio between the total area of the particles and the volume or mass of the soil.

The coarse fractions (boulders and sands) dominate in soils with low specific surface area, which gives them high permeability and a predominantly friable behavior (dependent on friction).

Fine fractions (silts and clays), in contrast, have a significantly larger specific surface area. This enhances the surface electrostatic forces, increasing cohesion and drastically reducing permeability.

In addition to the size, the geometric shape of the particles exerts a direct influence on the packaging (structure) and interlocking of the grains, crucial factors for the shear and compressive strength of the soil. For the coarser fractions (boulders, sands, and silts), the grains tend to be equidimensional (approximate dimensions in all directions). The geometry, which varies from angular to spherical depending on energy and transport time, affects friction. More angular particles result in a higher meshing and, consequently, in greater strength and lower compressibility for a given porosity.

Clay particles, on the other hand, exhibit a unique morphology: they are lamellar or placoid. In these submicroscopic grains, two dimensions far outweigh the third, resembling laminae or platelets. This morphology gives clay its colloidal properties and its remarkable plasticity, allowing that, in the presence of water, the particles organize themselves into complex structures (flocculated or dispersed) that dictate the cohesion and moisture retention capacity of the fine soil.

### 2.1.2 Chemical and Mineralogical Composition

Soils whose mineralogical composition demonstrates enrichment in silica, kaolinite or quartz tend to present a favorable reactivity to cement treatment, culminating in adequate geotechnical stability (Pinto, 2006).

Silica and Quartz: Quartz, while structurally stable, indirectly contributes to stability. Silica, in its amorphous or high-reactivity form (common in weathered residual soils), allows the occurrence of essential pozzolanic reactions with the calcium hydroxide released by the cement. Such reactions are responsible for the synthesis of hydrated calcium silicates (C-S-H), the main cementing component that gives strength and durability to the soil.

Kaolinite: This clay mineral has a stable crystal structure and a low specific surface area, compared to other clay minerals. Kaolinitic soils tend to present less ionic interference in the hydration kinetics of cement, promoting a more efficient pozzolanic reaction and a more predictable strength gain (Pinto, 2006).

The presence of these minerals is therefore associated with a lower binder demand and a superior performance of the stabilized material.

On the other hand, the presence of certain clay minerals and organic compounds can inhibit or severely compromise the stabilization process, classifying these soils as unsuitable for treatment with cement (Pinto, 2006).

Montmorillonite: This clay mineral is characterized by its expansive structure and high specific surface area. Its remarkable ability to adsorb water between the interlamellar layers gives it a high potential for expansion and retraction. In the presence of cement, montmorillonite competes for hydration water and, due to its high reactivity, can adsorb essential ions from cement, inhibiting the formation of C-S-H. This structural and chemical interference severely compromises the final strength and durability of the cemented soil.

Organic Matter: The high content of organic matter is a factor that chemically inhibits the hydration of cement. Organic components, in particular humic and fulvic acids, can act as chelating agents, encapsulating cement grains and slowing or paralyzing the hydration reaction.

## 2.2 PORTLAND CEMENT

Portland cement is known worldwide as a fine powder material, with different shades of gray, which manifests binding properties when mixed with water, and is often referred to as just 'cement' (Barbosa, 2015). This agglutination characteristic defines it as a binder, given its ability to bond other materials.

The final properties and characteristics of Portland cement are directly related to the characteristics and properties of the raw materials and the production process. According to the American Concrete Institute (ACI), Portland cement is a hydraulic binder obtained by grinding Portland clinker, composed essentially of hydraulic calcium silicates and aluminates. The process includes the addition of small amounts of calcium sulfate (gypsum) and often higher percentages of mineral additions, such as Granulated Blast Furnace Slag (EGAF), pozzolans and/or limestone filler.

Also in the composition, gypsum is added to Portland clinker in percentages of 2% to 6% before grinding with the fundamental objective of controlling the cement hardening (setting) time. Adding small amounts results in very rapid hardening, while high amounts can promote cracking in the hardened cement paste.

In addition to gypsum, mineral additions constitute a strategic and increasingly relevant component in the formulation of contemporary Portland cement, acting as essential modifiers of its physical and chemical properties. The impact of these additions on cement performance is two-phase. In general, a reduction in the initial mechanical strength of the material is observed, since the pozzolanic reaction and hydraulic latency occur at a slower pace than the primary hydration of the clinker. However, the long-term technical benefit is significant: the additions promote a progressive and noticeable increase in long-term mechanical strength and dramatically increase the durability of the hardened cement paste. This increase in durability is associated with the densification of the microstructure, reduced porosity and greater resistance to chemical attacks, allowing the production of optimized cements for more aggressive environments.

## 2.3 CRUSHED POWDER

Crushed stone dust is a fine aggregate that originates directly from the rock crushing process. This material, characterized by its fine granulometry, has important technical functions when incorporated into cementitious or soil-cement mixtures, such as those used in the production of bricks or other precast elements.

Its use is strategic and brings significant benefits to the properties of the final mixture: a) Improvement of Granulometry: The insertion of gravel dust contributes to the optimization of the global granulometric curve of the mixture. By filling the voids between the larger particles of the other aggregates (sand or coarse gravel), it promotes a denser and more homogeneous distribution of materials; b) Increased Compactness: As a direct consequence of the granulometric improvement, the gravel dust increases the compactness of the mixture. Greater compactness results in fewer voids, which is critical to the durability and mechanical performance of the final product. c) Shrinkage Reduction: The presence of fine and well-distributed aggregates, such as gravel dust, helps to restrict the amount of cement paste needed and to control water loss, helping to reduce shrinkage during drying and curing. This minimizes the risk of cracking. d) Contribution to Strength: The increase in compactness and densification of the structural matrix, together with the filling of voids, increase the final mechanical strength of the brick or component.

According to Menossi (2004), the use of gravel dust as a fine aggregate in concrete is of great interest both for its economic and environmental aspects because it is a material from tailings, which originally brought inconvenience to the quarries due to storage and disposal, but became a product endowed with a more affordable final value.

## 2.4 SOIL STABILIZATION

According to Brito and Silva (2017), soil stabilization is a process carried out to stabilize and supplement the resistance properties of the soil, adapting it for a given use.

The main objective is to improve critical characteristics such as mechanical strength, durability and compressibility, making the soil able to support structural loads more efficiently. Among the various methodologies for soil improvement, chemical stabilization with Portland cement stands out as one of the most effective and widely used in Brazil (Pinto, 2006). This technique consists of adding cement to the soil, resulting in the formation of the composite material known as soil-cement.

## 2.5 SOIL-CEMENT

Soil-cement is a fundamental technique of civil engineering, based on soil stabilization through a controlled and homogeneous mixture of soil, cement and water, followed by a rigorous compaction process. This methodology aims to transform the geomechanical properties of the original material, giving it greater strength and durability.

The improvement of soil properties occurs as a function of the cement's hydration mechanism in the presence of water. This chemical reaction is responsible for the formation of hydrated crystals that fill the voids and establish a rigid cementitious matrix, which permanently binds the soil grains. Consequently, this stabilization causes a drastic reduction in the permeability and susceptibility of the soil to moisture variations, which is crucial to limit expansion in sensitive clay soils.

Although there is no absolute consensus as to its initial framework for large-scale application, the use of soil-cement in civil construction gained national prominence in Brazil from the 1930s onwards. This period coincided with the regulation of its manufacturing process by the Brazilian Association of Portland Cement (ABCP), a factor that boosted the development and acceptance of the technique, as referenced by Lima, cited in Nascimento (2018).

In addition to its high structural performance, soil-cement stands out for its low environmental impact, as highlighted by Nachtigal (2014). The predominant use of the local soil itself as the main aggregate significantly reduces the need for conventional material transportation, which in turn minimizes greenhouse gas emissions associated with logistics.

Structurally, the consolidated material offers a durable and cost-effective solution, being widely employed as a base layer and sub-base in road pavements and in the production of no-burn building blocks, reinforcing its position as a sustainable and efficient technique for the improvement of infrastructure and civil construction.

### 2.5.1 Soil-cement brick

The soil-cement brick (or soil-cement block) has established itself as a technological and sustainable alternative in civil construction, distinguishing itself from traditional ceramic materials mainly by its manufacturing method. The process begins with the pressing of the homogeneous mixture of soil, cement and water in specific metal molds.

The quality of the final block depends intrinsically on the particle size characteristics of the soil used. The most suitable soils must have basic specifications, according to Silva (2005): a) Sand Content: between 45% and 90%. b) Silt + Clay Content: between 10% and 55%. c) Clay content: less than 20%. d) Liquidity Limit (LL): less than 45%.

The fundamental step that replaces the firing step of conventional bricks is wet curing. After molding and pressing, the bricks should be kept in an environment with high humidity for at least 7 days (Nachtigal, 2014). This period is crucial as it allows the cement hydration reactions to occur, creating the cementitious matrix that gives the block its ultimate strength and durability. The cure can be extended to optimize the desired strength.

The rigid cementitious matrix gives the brick a set of properties that make it superior in several aspects. It has high durability and resistance to compression, in addition to being less susceptible to disintegration by weathering. The modular design of the blocks also contributes to good thermal insulation in buildings, helping with energy efficiency.

In terms of economic viability, the advantage is twofold: a) Cost Reduction at the Base: Elimination of the burning process, which consumes a large amount of energy (wood or gas), reducing the cost of production; b) Economy on Site: The precise shape of the soil-cement brick allows a perfect fit, resulting in a significant reduction in the use of laying mortar and coating (roughcast/plaster), minimizing waste.

## 3 MATERIALS AND METHODS

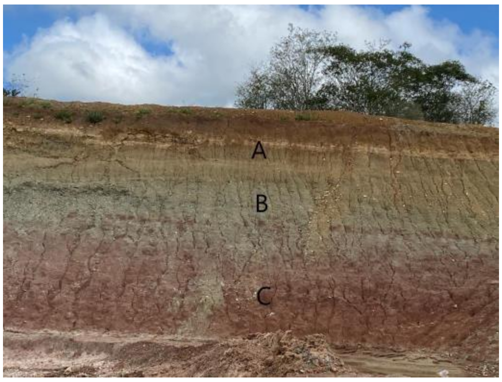
### 3.1 MATERIALS

### 3.1.1 Soils

The soil used as raw material was collected from the mining company located in the rural area of Araripina – PE, as shown in Figure 1.

**Figure 1**

*Site of extraction of the studied material. Representation of horizons A (yellow), horizon B (greenish) and horizon C (red) of the Araripina region*



Source: Authors (2025).

### 3.1.2 Other Materials Used

Throughout the research, composite Portland cement of two different types was used:

- CP II-Z 32 (Portland Cement Composite with Pozzolanic Material).
- CP II-F 32 (Portland Cement Composite with Filler).

The gravel dust used was collected in a mining company located in Ouricuri – PE, as can be seen in Figure 2.

**Figure 2**

*Place of extraction of the studied material: Sample crushed stone dust*

Source: Authors (2025).

## 3.2 METHODS

### 3.2.1 Characterization of the samples

The tests are described below, and for sample preparation, the procedures described in the Brazilian standard NBR 6457 (2016) are observed, such as pre-drying, unraveling and sieving in the 4.8 mm sieve, which can be seen in Figure 3.

**Figure 3**

*Clearance of the soil horizons of the Araripina region: A) horizon A. B) horizon B. C) horizon C*

(A) (B) (C)

Source: Authors (2025).

## 3.3 PHYSICAL CHARACTERIZATION OF THE SAMPLES

The tests presented in table 1 are used for the physical characterization of the soil.

**Table 1**

*Standards for soil characterization*

| Propriedades | Normas |
|---|---|
| **Umidade higroscópica** | ABNT NBR 6457/1986 |
| **Massa especifica** | ABNT NBR 6458/2016 |
| **Analise granulométrica** | ABNT NBR 7181/2016 |
| **Limite de liquidez** | ABNT NBR 6459/1984 |
| **Limite de plasticidade** | ABNT NBR 7180/2016 |

Source: Authors (2025).

## 3.4 RETRACTION

The fundamental principle observed is the phenomenon of soil retraction, which manifests itself as the reduction in volume of a mass of soil as a result of moisture loss. This volumetric decrease, when it occurs in a confined or uneven manner, is the direct cause of the potential appearance of cracks or fissures on the surface of the analyzed sample.

**Figure 4**

*Wooden box*

Source: Authors (2025).

The procedure, known as the Channel Test, as can be seen in Figure 5, begins with the preparation of the sample. Then, the initial consistency is determined, the soil is gradually mixed with water in a metal tray, using a trowel, until it reaches the point where the mixture has a mortar consistency, characterized by its adhesion to the instrument.

For molding, the wooden box is previously lubricated with oil, as observed in Figure 4. The soil in the given consistency is thrown into the box at a height of 30 cm and carefully planed.

**Figure 5**

*Procedure of the retraction test*

Source: Authors (2025).

After molding, the specimen is subjected to the curing phase, being kept sheltered from the sun and rain for a period of 7 days, which ensures a slow and controlled drying in the air.

The result of the test is measured at the end of this period, based on two criteria: the analysis and measurement of the retraction observed in the two directions of the sample inside the box and the verification of the appearance (or absence) of cracks or fissures on the surface of the specimen. This adapted test provides valuable data to infer the behavior of the soil in terms of its volumetric stability.

## 3.5 DEFINITION OF TRAITS

In the first phase, bricks were manufactured by mixing the A, B and C horizons with different lines: 1:6, 1:8, 1:10 and 1:12.

Subsequently, soil-cement bricks were manufactured with the addition of gravel powder using the 1:6:0.5 traces; 1:6:0.25 (cement, soil and gravel dust).

## 3.6 SOIL-CEMENT BRICK MAKING

For the production of bricks, a manual press was used with molds of dimensions 12.5 cm x 25 cm x 6.5 cm (width x length x thickness) and fittings that allow direct tying between the components in the execution of the masonry, as can be seen in Figure 6.

**Figure 6**

*Manufacture of bricks. (A) Manual press (B) Molding (C) Brick*

(A) (B) (C)

Source: Authors (2025).

After manufacturing, wet curing was carried out, where the bricks were wrapped with a plastic, sheltered from the sun and wind for 7 days.

## 3.7 DIMENSIONAL ANALYSIS

The Dimensional Analysis Test is a fundamental quality control procedure that aims to verify that the geometric dimensions of the brick conform to the nominal dimensions specified in the standard.

NBR 8491/2012 establishes that the brick is a rectangular parallelepiped. Dimensional stiffness is ensured by extremely tight tolerances, with a maximum deviation of only 1.0 mm from the nominal dimensions of length, width and height being permitted. This precision is essential to ensure the plumb, level and uniformity of the wall, minimizing the need for adjustments on site and the excessive consumption of laying mortar.

## 3.8 COMPRESSIVE STRENGTH TEST

Before the compression test, seven bricks were prepared according to the specifications of NBR 8492 (ABNT, 2012). The bricks were cut with the aid of a circular saw (Makita) in order to obtain uniform halves. From these halves, the specimens were made, using a cement paste as the binding material between the surfaces, as can be seen in Figure 7. After molding, the paste remained curing for approximately 24 hours, ensuring sufficient strength for handling and subsequent steps.

**Figure 7**

*Compressive strength test procedures*

(A) Brick cuts (B) Bricks + cement paste (C) Curing process

Source: Authors (2025).

**Figure 8**

*Compressive strength test*

Source: Authors (2025).

## 3.9 WATER ABSORPTION

The method used for the test to determine the water absorption in the blocks is prescribed by the NBR 13555 (ABNT, 2012) and NBR 8492 (ABNT, 2012) standards. The water absorption test aims to determine the amount of water that soil-cement bricks are able to absorb when subjected to controlled immersion, observed in Figure 9. This parameter is essential to evaluate the quality of the material, since high absorption rates can indicate lower density, higher porosity and, consequently, lower durability and mechanical resistance of the brick.

The values of the average absorption percentage of the specimens cannot exceed 20%, and individually cannot exceed 22%.

**Figure 9**

*Absorption assay procedure*

Source: Authors (2025).

## 4 RESULTS AND DISCUSSIONS

### 4.1 HYGROSCOPIC MOISTURE AND SPECIFIC MASS ANALYSES

Table 2 presents the results of hygroscopic moisture and specific mass of horizons A, B, C, A+B+C, A+B+C+gravel dust from the region of Araripina (PE).

**Table 2**

*Experimental values obtained for hygroscopic moisture and specific mass for the Araripina regio*

| Horizon | Hygroscopic Humidity (%) | Specific mass (g/cm3) |
|---|---|---|
| **A** | 2,24 | 2,42 |
| **B** | 2,47 | 1,85 |
| **C** | 2,05 | 1,75 |
| **A+B+C** | 2,31 | 2,55 |
| **A+B+C+crushed stone dust** | 3,28 | 2,57 |

Source: Authors (2025).

### 4.2 PARTICLE SIZE ANALYSIS

From the particle size test by screening and sedimentation, the distribution of grain diameters and their respective soil percentages in each specific size range was determined. Figure 10 shows the granulometric curve of the soils analyzed. Analyzing the graph, it is possible to notice that 100% of the soil samples pass through the 4.8 mm sieve, according to the recommendations for the production of cement soil bricks of NBR 10833/2012.

It is observed that, in the mixtures of the A+B+C and A+B+C horizons plus gravel dust, the percentage of material passing through the 0.075 mm sieve was lower than that established by ABNT NBR 10833 (2012), evidencing a deficiency of clay fraction in the samples. With this test, we have that the soils of horizons "A" and "C" have approximately 80% sand and the soil of horizon "B" has approximately 70% sand. Showing the clay deficit in these soils, since according to the Soil-cement Brick Production Booklet, the quantities should be approximately 25% clay, 25% silt and 50% sand. (IEP, 2016).

**Table 3**

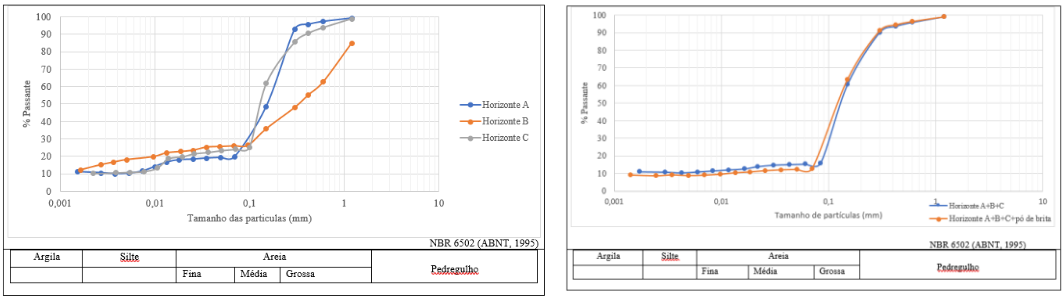
*Composition of the samples according to particle size*

| Composition | Diameter (mm) | Sample A (%) | Sample B (%) | Sample C (%) | Sample A+B+C (%) | Sample A+B+C+powder gravel (%) |
|---|---|---|---|---|---|---|
| Clay | <0.02 | 10 | 15 | 10 | 11 | 11 |
| Silt | ≥0.002 to ≤0.06 | 10 | 15 | 10 | 5 | 5 |
| Sand | ≥0.06 to ≤2.0 | 80 | 70 | 80 | 86 | 86 |

Source: Authors (2025).

**Figure 10**

*Particle size analysis: (A) of the A, B and C horizons of the Araripina region (B) of the A+B+C and A+B+C+gravel dust horizons*



(A) (B)

Source: Authors (2025).

## 4.3 CONSISTENCY LIMITS

The results of the plasticity limit, liquidity limit, and plasticity index tests of the samples are presented in Table 4. The plasticity limit is related to the amount of water added to the clay for the molding stage, which is important for processing in technological applications (SANTOS, 1989).

**Table 4**

*Atterberg Indices*

| Parameter | Requirement (%) | Horizon A | Horizon B | Horizon C | Horizon A+B+C | Horizon A+B+C+residue ceramic |
|---|---|---|---|---|---|---|
| Limit | ≤ 45 | 33,38 | 48,58 | 36,80 | 39,80 | 32,67 |

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| liquidity(%) (LL) |  |  |  |  |  |  |
| Plasticity Limit(%) (LP) |  | 26.36 ± 0.93 | 27.73 ± 4.10 | 29.34 ±2.04 | 23.35±0.25 | 23.38±0.80 |
| Index of Plasticity(%) (IP) | ≤18 | 7,02 | 20,85 | 7,46 | 16,45 | 9,29 |

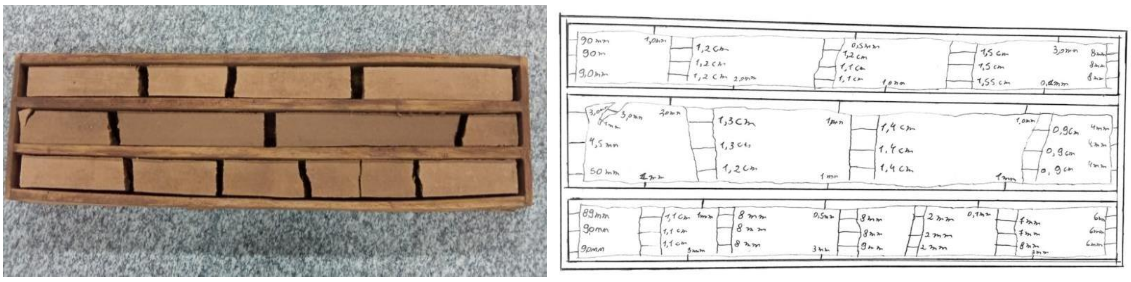
Source: Authors (2025).

## 4.4 RETRACTION TEST

After the full seven days of soil in the box, it is recommended that there are no cracks in the soil or that it moves more than 20 mm away from the channel. However, the appearance of cracks and retraction in soil masses can be identified, as can be seen in Figure 11.

**Figure 11**

*Result of the soil shrinkage test*



Source: Authors (2025).

It was observed that the test carried out with the soil under study showed the formation of cracks and the separation of the ends of the gutter, varying between 0.5 mm and 1.55 cm, which led to its disqualification in the test, as can be seen in Figure 11. However, it is noteworthy that soil stabilization with cement tends to minimize the effects of shrinkage, contributing to a more adequate structural performance.

## 4.5 DIMENSIONAL ANALYSIS

NBR 8491 (2012), for each dimension of the specimens, it was essential to perform at least 3 determinations at different points on each face of the samples. Table 5 shows the means of the categories of length, width, and height for each line, obtained with the aid of the digital caliper, in tenth of a unit, expressed in millimeters (mm).

**Table 5**

*Dimensional analysis (cm) - Mean values*

| Trace | Length (cm) | Width(cm) | Height (cm) |
|---|---|---|---|
| 1:6 | **25,10** | **12,60** | **6,82** |
| 1:8 | **25,20** | **12,60** | **7,06** |
| 1:10 | **25,19** | **12,60** | **7,01** |
| 1:12 | **25,04** | **12,60** | **6,95** |

| | | | |
|---|---|---|---|
| 1:6:0,25 | **25,20** | **12,60** | **7,14** |
| 1:6:0,50 | **25,35** | **12,60** | **7,00** |

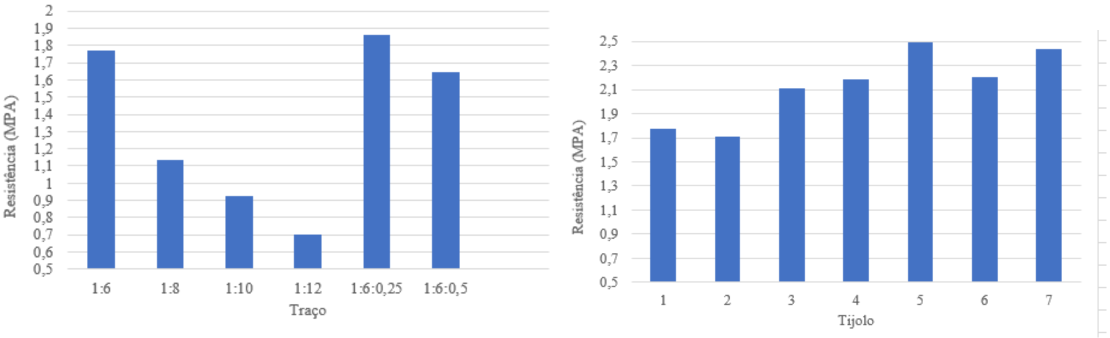
Source: Authors (2025).

## 4.6 COMPRESSIVE STRENGTH

Observing the mean resistance for each trait, it was found that only the 1:6 and 1:6:0.25 traits obtained satisfactory results higher than the minimum of 1.7 Mpa, as can be seen in Figure 12. For the 1:6:0.25 trace, it can be observed that only 2 samples obtained a result higher than 1.7 Mpa and the other samples obtained values higher than those required by the NBR 8497/2012 standard.

**Figure 12**

*(A) Graph of the mean compressive strength. (B) Graph of the mean compressive strength (1:6:0.25)*



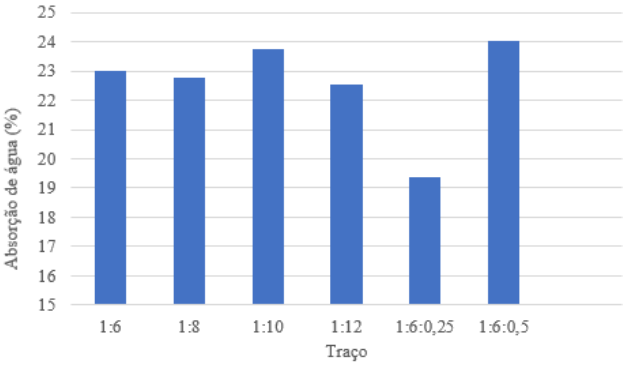
Source: Authors (2025).

## 4.7 WATER ABSORPTION

According to NBR 8491/2012, the average water absorption values of soil-cement bricks should not exceed 20%, and no individual unit can present absorption higher than 22%, as observed in Figure 13.

**Figure 13**

*Absorption graph*



Source: Authors (2025).

Among the samples submitted to the water absorption test, the 1:6:0.25 Trace was the only one to present satisfactory performance, reaching the requirements established by the current technical standard. This result validates the effectiveness of this mixture in reducing the porosity of the material, ensuring its durability and suitability for the proposed use.

## 5 CONCLUSION

Based on the results obtained, it is concluded that the soils of the A, B and C horizons of the region of Araripina (PE) have predominantly sandy characteristics, with a deficit of clay fraction in relation to the recommendations of the technical literature for the production of soil-cement bricks. The particle size analysis showed that all samples met the requirement of 100% through the 4.8 mm sieve, according to ABNT NBR 10833/2012; however, the percentage of material passing through the 0.075 mm sieve was lower than the minimum recommended for the mixtures A+B+C and A+B+C+gravel powder, indicating low potential plasticity and lower natural cohesion of the soil.

The consistency limit tests showed that the B horizon presented a plasticity index higher than the recommended limit, while the mixtures A+B+C and A+B+C+residue remained within the normative parameters.

In the shrinkage test, it was observed the formation of cracks and separation of the ends, leading to the disqualification of the natural soil, which reinforces the need for stabilization to improve technological performance.

In mechanical performance, it was found that only the 1:6 and 1:6:0.25 traces met the minimum requirement of compressive strength established by NBR 8497/2012 (≥ 1.7 MPa), and the 1:6:0.25 trace presented more consistent results.

Regarding water absorption, only the 1:6:0.25 trace fully complied with the limits of NBR 8491/2012, demonstrating better performance in terms of durability and lower porosity.

Thus, it is concluded that, despite the granulometric limitations and the clay deficiency of the soils studied, the stabilization with cement, especially in the 1:6:0.25 trait, proved to be technically feasible for the production of soil-cement bricks in the Araripina region, meeting the main normative requirements of strength and absorption. It is recommended, for future work, the granulometric correction of the soil with the addition of fine material or adjustments in the stabilizer content, in order to further optimize the mechanical and physical performance of the products.

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