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CREATION OF HANDMADE BRICKS WITH COFFEE HUSKS AND CLAY, IMPLEMENTING THE COMPRESSED EARTH BLOCK METHOD. A SUSTAINABLE ALTERNATIVE FOR RURAL COMMUNITIES

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Abstract

The construction systems and processes was one of the categories of the project fair, where the construction of medium complexity housing was evidenced, in which 20 civil engineering students of the sixth semester participated in the subject of construction 1. and evaluation of the teacher, the strengthening of their competencies is identified, mainly that of analyzing, projecting and designing civil engineering works, using the appropriate information for the solution of application problems, the ability to identify, plan and solve problems, among others, being a contribution to their professional development. The construction sector generates some greenhouse gases into the atmosphere, such as carbon dioxide and sulfur, and, due to the high demand for energy and natural resources required for its development, there arises the need to investigate alternatives that promote the use of waste for the development of building materials that meet technical standards, thereby mitigating the environmental impact in each of the construction processes that are used in traditional construction and the environment where they are executed, contributing to the preservation of species and ecosystems. This article seeks to generate a practical and pedagogical application in the development of an eco brick based on coffee husk and clay implementing the technique of compressed earth blocks (BTC), in order to provide innovative processes in the construction of sustainable housing for the benefit of rural communities, due to its low cost of manufacture, ease of processing, availability and accessibility of resources and that these are articulated to the circular economy of processes and waste generating a positive impact from the environmental, this research has a methodology practice which had development steps such as 1: bibliographic research 2, technical tests under the Colombian technical standards 4205. 3, testing of prototypes 4 realization of prototypes according to mix design allowing as results that demonstrate the ease of implementation process, its impact and above all the applicability for rural communities, which allow to venture into the circular economy, thus demonstrating the theory of learning by doing and applying concepts of innovation, sustainability, and eco-materials.

Key words: Coffee husk, Bricks, procedure, technique, earth block, eco materials.

1. INTRODUCTION

One of the sustainability goals proposed by the United Nations Organization, was to achieve by

2030 the attainment of sustainable cities and communities, in view of the fact that, these urbanizations generate 70% of global carbon emissions, 80% of energy consumption and more than 60% of resource use. (United Nations Organization (UN) , 2015). These figures have caused great concern to governments, since statistics indicate an increase in the coming years, which translates into climate changes of great impact on society and the economy, from the melting of the poles, temperature increase, droughts, floods, extinction of plant and animal species, poverty and proliferation of diseases (Shaftel, Callery, Jackson, Bailey, & Callery, 2023). For this reason, if we continue with traditional construction trends and the excessive exploitation of resources, we will be approaching a point of no return, a situation that we hope to avoid completely. Colombia has a great diversity of resources, among which the richness of its soils and the productivity of coffee stand out. Colombia is the third country with the highest coffee production in the world, which annually generates 13.5 million bags of coffee husks, each weighing 60 kilos, according to the National Federation of Coffee Growers (Federación Nacional de Cafeteros de Colombia, 2022). that is, in the production and treatment process, only 5% is usable for the manufacture of the beverage, the remaining 95% corresponds to husks, stems and pulps that represent the waste of the utility (Cerquera Vargas, 2022). On many occasions, this waste ends up being dumped in water sources, causing a negative impact on ecosystems (Fernández Cortés, Sotto Rodríguez, & Vargas Marín, 2020). Therefore, it is necessary to encourage projects that tend to increase the 122 projects that, as of 2018, were registered with LEED certification (sustainable building certification system created in 1993 by the U.S. Green Building Council) and the 299 in the process of certification, as established by the U.S. Green Building Council (Amarilo, 2021). In order to comply not only to Colombia, but also to the world, with the development of the sustainability objectives agreed by the United Nations (UN).

The coffee husk is a by-product obtained when the coffee cherry is subjected to a pulping process, in which the seeds are extracted, and from the residue of this process, the coffee husk is obtained, representing 12% of the product (Penedo Medina, Manals Cutiño, & Salas Tort, 2018). Likewise, clay is a sedimentary rock, which is made up of aluminum silicates, quartz, calcite, dolomite, gypsum and iron oxide (Linares González, Linares González, Capel Martínez, & Capel Martínez, 2013). (Linares González, Huertas García, & Capel Martínez, 2013). For the elaboration of constructive elements, the clay is mixed with water in order to obtain a moldable paste, then it is subjected to high temperatures in order to extract the water present in it, thus undergoing a change in volume, to finally reach a crystalline texture (Vidrio, 2002). Thus, clay acquires outstanding properties of hardness and resistance to loads, which makes it a viable product for engineering and architectural projects, as well as economically profitable, due to its low cost.

Compressed earth blocks are a technique that does not use ovens to cook the clay bricks, but rather uses the compression of the material, with the addition of binders that provide adherence to the particles, strength and durability, as is the case of cement (Arteaga Medina, Medina, & Gutiérrez Junco, 31). With this process, it is possible to reduce by 99% the emissions of carbon dioxide, sulfur dioxide and fly ash that cause respiratory diseases to people living near these factories, thus preserving air purity and reducing energy, since these blocks have bio-climatic properties that favor warm environments for areas affected by high temperatures (Mompó García , 2015).

This research serves as a guide for rural communities on how to take advantage of agro-industrial and subsoil resources for the construction of non-load-bearing buildings that provide comfort and safety to those who use them, promoting the learning of these techniques that reduce the environmental impact caused by the construction industry over the years, being an accessible and viable alternative from the approach of sustainability.

2. METHODOLOGY

This article develops a pedagogical guide for the elaboration of handmade bricks with coffee husk and clay, in the modality of compressed earth block, for the construction of houses of the

communities of the rural zone of Colombia, entering this population in the field of sustainable construction.

Stages of the methodology used.

Stage I: Study of the current regulations in Colombia for the manufacture of masonry bricks. masonry bricks.

Stage II: Establishment of the steps to follow for the elaboration of handmade bricks based on coffee husk and clay, using the compressed earth block technique.

Stage III: Recommendations on the elaboration of the bricks, in order to achieve the maximum yield.

Procedure for the production of compressed earth blocks based on coffee husk and clay.

General Specifications.

- The compressed earth blocks (BTS) Being an artisanal technique, they do not have an established technical standard (NTC), therefore, NTC 5324 soil-cement blocks for walls and partitions and NTC 4205 baked clay masonry units. bricks and ceramic blocks can be taken as a reference**.**
- Its manufacturing process does not require skilled labor or transportation costs, since the bricks can be manufactured at the construction site, resulting in lower costs.
- The use of a CIMVA-RAM manual press suitable for the manufacture of compressed earth blocks (BTC) would optimize the process, achieving a reduction in time (see Figure 1).

Figure 1. CIMVA-RAM Manual Press for BTC.

The test described in the UNE 41410 standard "Resistance to wetting/drying cycles", in which it is determined whether a block is suitable or not to be implemented in construction, when it is submerged 6 times for 30 seconds at a depth of 10 mm, and after the last submersion, being completely dry, it does not show cracks, changes in volume, loss of material or absorption of large amounts of water. It is there where, not presenting any of these pathologies, the blocks can be used in the construction of houses (Tutor Vicente, 2015).

Tools and Equipment

- Manual press CIMVA-RAM

- Ceiba wood mold.

- Sieves.

- Trowel

- Shovels

- Mixing vessels

- Scales.

3. MANUFACTURING TECHNIQUE

- **Selection of the raw material.**

As a first step for the elaboration of compressed earth blocks based on coffee husk and clay, it consists of choosing the appropriate materials that ensure the maximum performance in the manufacturing process. For this purpose, it is necessary to choose the material that presents a large amount of clay and silts, which allow a plastic behavior and greater adherence between the particles. Likewise, select coffee husks that do not present impurities and elements different from the same, which could damage the performance of the material. For this purpose it is advisable to

sieve the raw materials before mixing them, as shown in figure 2.

Figure 2. Screening of clay and coffee husk.

- **Determination of the optimum humidity.**

Before approaching this step, it is necessary to let the clay dry at room temperature for at least 24 hours. After this time has elapsed, water is added uniformly to the clay to be worked, then, a sample of it is selected, which will be compacted with the hands, as shown in figure 3, then, this handful of soil will be dropped to a height of approximately 1 meter. If the soil disintegrates into several pieces when it hits the soil, it means that the mixture lacks water; if, on the contrary, the fingers are marked on the ball of soil, and when it hits the soil it does not fragment, it means that there is excess water.

Figure 3. Determination of optimum moisture content of the mixture.

- **Mixing of the raw materials.**

After determining the optimum humidity, the clay previously dried at room temperature is mixed with 15% of the weight in coffee husks, as shown in figure 4, adding the amount of water determined in step 2. Likewise, 12% of cement and 3% of lime are added, since these compounds will allow a better adherence of the particles and a better control of the humidity of the mixture.

Figure 4. BTC commodity mix

- **Modular dimensions of the compressed earth block.**

The dimensions used for the manufacture of the blocks are based on the Colombian technical standard NTC 296, Modular dimensions of masonry units of baked clay, bricks and ceramic blocks, section 5, which are illustrated in Figure 5.

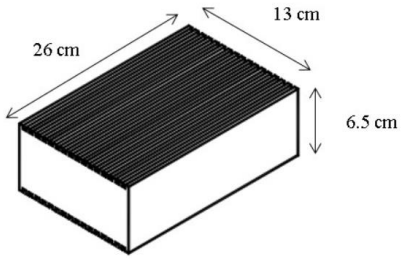

Figure 5. Modular dimensions of the bricks.

Likewise, it is advisable to use Ceiba type wood molds, because thanks to their high water resistance properties, they will not present deformations that affect the accuracy of the brick dimensions, and, therefore, will not properties of high resistance to water, they will not present deformations that affect the accuracy of the brick dimensions, and, therefore, the useful life time of the molds is not reduced, as shown in figure 6.

Figure 6. Wooden brick molds in Ceiba type.

- **Molding of the bricks based on coffee husk and clay.**

If it has a CIMVA-RAM machine, the mixture is deposited inside the mold of the manual press, as shown in figure 7, and with the lever of the same one, the materials are compressed with the platens of the machine, as shown in figure 8, and immediately, when demolding it, the block of compressed earth is obtained, as it is evidenced in figure 9.

Figure 7. Deposition of the material in the CIMVA-RAM manual press.

Figure 8. Compression of the bricks with the hand press lever.

Figure 9. BTC obtained after demolding the specimen from the manual press.

In the case of not having a CIMVA-RAM press, the compaction is done manually, in which the mixture is poured in three layers, in the wooden molds, each one of approximately 2 cm, being compacted with 25 blows with a wooden support or a 20 kg rammer, in order to eliminate porosities

and achieve maximum compaction, as shown in Figure 10.

Figure 10. Compaction of the mixture in the wooden molds.

The shape and compaction of the bricks should be as shown in Figure 11.

Figure 11. BTC bricks contained in wooden molds.

If the blocks are made by either or both of the two methods, they must be completely dried after being demolded, in order to ensure the maximum resistance of the cement and the adherence of the raw materials that make up the cement (clay and coffee husks), thus avoiding structural problems in the future. It is recommended to let them dry at room temperature for at least 5 days, protecting them from humidity, rain and water sources close to their place of deposit.

Figure 12. Drying of the bricks at room temperature

After these steps, the handmade bricks made from coffee husks and clay are ready to be used in the construction of houses

Benefits of compressed earth blocks.

•Environmental preservation properties, due to their low pollution emission, as they are not manufactured under the firing processes used in traditional clay bricks.

•Compressed earth blocks have great durability, efficiency and safety, characteristics that are evident in the construction of great empires, such as the Roman Empire and in buildings such as the pyramids of Egypt.

•Structures built with these elements do not rot over time.

•These blocks have the capacity to absorb and release humidity and heat, which provides warm spaces and pleasant environments inside the enclosure, thus reducing the use of energy to acclimatize the houses.

•As they are manufactured at the construction site, they help to reduce transportation costs, thus reducing processing costs. Taken from: (Sanchez & Valero Guerra, 2020).

CONCLUSIONS

The materials used in these blocks (coffee husk and clay) are characterized by being biodegradable, that is, at the end of their useful life, they can continue to be used in the manufacture of other products without causing negative impacts on the environment, which is called contributing to sustainability. Likewise, the construction of housing for communities in rural areas of the country, implementing these bricks, is a viable alternative from the social, economic and environmental approach, due to the great availability and accessibility of raw materials for the manufacture of these bricks and the ease of the manufacturing process.

This research is a guide for the manufacture of handmade bricks with coffee husks and clay, implementing the compressed earth block technique (BTC), in which some recommendations and images are presented to illustrate and guide those interested in the experimental process of the step by step of how to make bricks with this material.

It should be noted that, although they are not very well known in the market, these bricks provide all the necessary properties of flexion, compression, and from the bioclimatic point of view, they can generate thermal and acoustic insulation, thus providing comfort to the spaces developed with them.

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