Analysis of the benefits of adding disposable materials applied in the production of ceramic bricks: Bibliographic Review

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Abstract

Civil construction is considered a major generator of negative environmental impacts, whether due to the large consumption of natural resources or the generation of a large volume of waste, it is mainly related to the inadequate exploitation of natural resources, the forms of use and mainly to their inefficient disposal. This work aims to analyze through a literature review the technical, economic and environmental feasibility of incorporating different disposable materials applied in the production of ceramic bricks obtained by recycling.

Keywords: Ceramic Brick; Materials; Clay.

1. Introduction

The Brazilian ceramic sector is among the largest in its category in the world, having great economic importance for the country, both in the generation of foreign exchange and in the generation of jobs and income. This sector is broad and heterogeneous and, therefore, is divided into several segments (abrasives, bioceramics, sanitary ware, refractory materials, red ceramics, coatings, ceramics for domestic use and the like, among others). The red ceramics segment has a prominent place in this scenario, with a participation of approximately 7000 companies, mostly micro and small family-run companies, which are responsible for almost 300 thousand direct jobs, 900 thousand indirect jobs, with a annual revenue of BRL 18 billion (ANICER, 2014).

In recent years, following industrial evolution, the ceramic industry has adopted mass production, guaranteed by the equipment industry, and the introduction of management techniques, including the control of raw materials, processes and manufactured products (SINDICERMF, 2015). This has artisanal and industrial prominence, the abundant availability of the raw material, makes it become more and more popular, with a diversification and direction in its industrialization (BAUER, 2011).

The raw materials, properties and area of use determine the division of the ceramic sector and give it the general classification adopted, which follows as: red or structural ceramic, coating material, white ceramic (tableware, bathroom chinaware, electrical insulator, artistic ceramics), refractory materials, thermal insulators, tapes and dyes, abrasives, glass, cement, lime and advanced ceramics (PRADO, 2013).

Clay is the main raw material used in the red or structural ceramics industry. Its constitution is given by clay minerals, which are hydrated silicates of aluminum, iron and magnesium, which may contain organic matter, soluble salts or other minerals (GOMES, 1988). Originating from weathering acting on rocks that contain feldspar (very abundant in the earth's crust). Weathering is the physical (eg erosion, decompression) and chemical (eg carbonic acid) action of the environment on rocks, forming very small particles called clay minerals. Clay is a hydrated aluminum silicate, composed of aluminum (aluminum oxide), silica (silicon oxide) and water, having kaolinite as a basic mineral. The main minerals found in clays are: silicon, aluminum, iron, magnesium, potassium and sodium (MAZER, 2015).

The bricks are produced from clay, usually in the form of parallelepiped, have a reddish color and have channels/holes along its length. Civil construction is the main target of red ceramic products, among these materials, bricks stand out, due to the number produced and sold. Fence blocks are those intended for the execution of walls that will support their own weight and small occupancy loads (cabinets, sinks, washbasins) are used in buildings in general, representing about 90% of constructions and roofs (FIEMG, 2013).

Figure 1 - Ceramic sealing blocks

Source: Aldebara Cerâmica (2015)

There is a very large variety of dies on the market, and as a consequence the types of blocks, with variations in the textures of the blocks faces, the quantity and type of holes, the thickness of the walls and also the dimensions, which ends up limiting the mastery of the engineering professional on this type of product (BAUER, 2011).

With regard to clay, a material used by the red ceramic industry for the production of ceramic blocks, its extraction causes damage to rivers, soil and forests near the cities where this activity is present. The environmental problems generated by the ceramic industries are: deforestation caused by mining ore causing pits in the ground and huge holes, deforestation caused by cutting vegetation to produce firewood as an energy matrix for industry, and disposing of waste (CASTRO, 2008). The environmental impacts caused by these interventions are desertification, atmospheric gas pollution, the greenhouse effect, landfills and siltation of streams and rivers. One of the alternatives to minimize these impacts is the reincorporation and/or reuse of waste in the production cycle, an option for the recovery of these materials must be represented both in the environmental and economic aspects. This reincorporation or reuse is given through the ceramic mass in formulations, with the objective of manufacturing products such as ceramic blocks, tiles and tiles, presenting them as viable options for the ceramic industry (OLIVEIRA, 2015). The objective of this work is to analyze sustainable researches by some authors using recyclable materials in the production of ceramic bricks.

2. Theoretical reference

2.1. Ceramic Industry

The ceramics industry is one of the oldest in the world, due to the ease of fabrication and the abundance of raw material – clay. In the Neolithic period, prehistoric man caulked wicker baskets with clay. Later he found that he could do without wicker, and made pots out of clay. Later, he found that heat hardened this clay, and the actual pottery emerged, which, in this phase of humanity, was widely used for the most diverse purposes (Bauer, 2011).

The ceramic industry occupies an important sector in civil construction, which generates thousands of direct and indirect jobs, concentrated in the production process of ceramic bricks, which due to the ease of execution of masonry, manufactured with clay and reddish in color due to cooking that can be massive or perforated, after the clay is extracted, it goes through a purification phase in order to rid it of impurities. Ceramics have accompanied humanity since prehistory (BAUER, 2015).

In the red ceramic industry, despite the varied production processes, whatever the process (from the most rudimentary to the most automated), three fundamental steps are always present, as shown in Figure 2.

Figure 2 - Basic steps in red ceramic production processes

Source: Adapted from SBRT (2012).

2.2. Ceramic Materials

Pottery, which is practically as old as the discovery of fire, even using ancient artisanal methods, can produce articles of excellent quality. In recent years, following industrial evolution, the ceramic industry has adopted mass production, guaranteed by the equipment industry, and the introduction of management techniques, including the control of raw materials, processes and manufactured products (SINDICER, 2015).

Associação Brasileira de Cerâmica (ABC) defines the term "ceramics" as all inorganic, non-metallic materials generally obtained after heat treatment (burning) at high temperatures. Currently, the term ceramic refers to all non-metallic inorganic material obtained after heat treatment at high temperatures, for example: floors, bathroom ware, glass, optical fibers, cooking utensils, nuclear fuel, bone and dental implants, among others. This class of materials has specific properties such as high chemical stability, corrosion and heat resistance, among others. Figure 1 shows general applications of ceramics (ALMEIDA, 2015).

According to ALMEIDA (2015), the Ceramic Industry in Brazil and in the world, currently, can be debt in several sectors that have some different characteristics and different levels of technology:

- Red Ceramics: Structural or red ceramics are a type of ceramics characterized by the reddish color of its products and which are used in civil construction, such as bricks, blocks, tiles, tubes, lining slabs, hollow elements, light expanded clay aggregates and others. These are products that offer good durability, thermal and acoustic comfort, low cost, among all those involved in the civil construction production chain (ABC, 2002).

- White Ceramics: This group is quite diversified, comprising materials consisting of a white body and generally covered by a transparent and colorless glassy layer, which were thus grouped by the white color of the mass, necessary for aesthetic and/or technical reasons. With the advent of opacified glazes, many of the products that fit into this group started to be manufactured, without prejudice to the characteristics for a given application, with raw materials with a certain degree of impurities, responsible for the coloration (SINDICER, 2015). Added to this group are: sanitary ware, tableware, electrical insulators, among others.
- Refractory Materials: materials capable of withstanding high temperatures, without losing their properties, are examples of these materials: ceramic ovens, boilers, high temperature ovens and barbecue grills (SINDICER, 2015).
- Advanced Ceramics: materials produced with the highest current technologies, where raw materials with very high purity and rigorous processes are used, thus obtaining high quality materials, such as: dental implants, bone replacement, spacecraft, in sensors, superconductors, among others (SINDICER, 2015).
- Ceramic Coatings: Ceramic tiles are generally made up of three layers: a) the support or biscuit, b) the engobe, which has a waterproofing function and ensures the adherence of the third layer, and c) the enamel, a glassy layer that also waterproofs, in addition to decorating one of the sides of the board. These coatings are used in civil construction for coating walls, floors, benches and swimming pools for indoor and outdoor environments. They receive designations such as: tile, mosaic, porcelain, stoneware, tile, floor, etc. The porcelain tile technology brought products of technical quality and refined aesthetics, which in many cases resemble natural rocks (SINDICER, 2015).

Figure 3 - General Applications of Ceramics

Source: Caram (2015)

2.3 Clay

Soil is of great importance in civil construction, as it is a material that is easy to extract and simple to prepare. Common examples of the use of lateritic soil are the manufacture of ceramic materials such as bricks and tiles or even for the construction of a paving base (NASCIMENTO, 2011).

Clay is a natural material, earthy texture, fine-grained, consisting essentially of clay minerals and may contain other minerals that are not clay minerals (quartz, mica, pyrite, hematite, etc.), organic matter and other impurities. Clay minerals are the characteristic minerals of clays; chemically they are hydrated aluminum or magnesium silicates, containing in certain types other elements such as iron, potassium, lithium and others (ABC, 2015).

The most important properties of clays are plasticity, shrinkage and the effect of heat. In ceramics, the interest lies in weight, mechanical strength, wear resistance, water absorption and duration (Bauer, 2011)

2.4. Ceramic Blocks

According to NBR 15270, the ceramic sealing block is the component of the sealing masonry that has prismatic holes perpendicular to the faces that contain them. The ceramic sealing block is produced to be used specifically with horizontal holes, where it can also be produced for use with vertical holes. Ceramic blocks for sealing are external or internal masonry that does not have the function of resisting other vertical loads, in addition to the weight of the masonry of which it is part (ANCELMO, 2015).

Table 1 - Characteristics of solid and hollow blocks

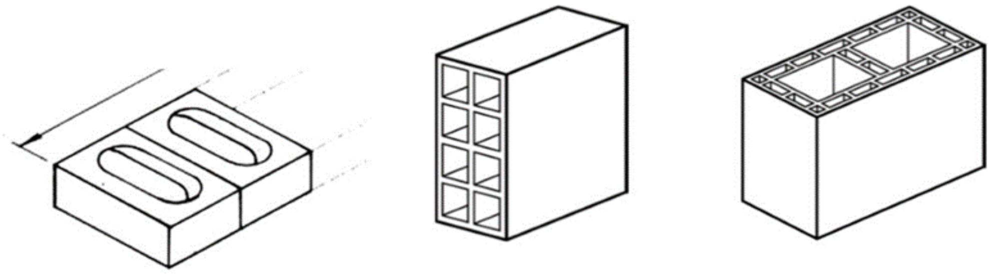
PRODUCT	FEATURES
MASSIVE (BRICKS)	• It has all sides full of material, and may have manufacturing recesses on one of the sides with the largest area; • They can be manufactured by extrusion or pressing; • The bricks must not show systematic defects such as cracks, breaks, uneven surfaces, deformations and unevenness in color; • They must have no efflorescence, uniform burning, parallelepiped shape and may have manufacturing recesses on one of the faces with the largest area; • Dimensions of common bricks: 19 to 9 by 5.7 cm and 19 to 9 by 9 cm; • Water absorption between 15 and 25%

LEAKS (SEAL OR STRUCTURAL)	• Have holes parallel to one of the faces; • Types: • Sealing - support only their own weight. Holes vertically or horizontally. (Figure); • Structural - support loads provided in structural masonry and have vertical holes, which can be of three types: blocks with solid walls; blocks with hollow walls and perforated blocks. (Figure) • Dimensions are varied, according to the matrix used specified in the standard; • Total water absorption: between 8 and 22%.

Source: NBR 15270

The following figures represent the different types of ceramic blocks, according to NBR 15270-3.

Figure 4 - Presentation of ceramic sealing blocks



a) Solid brick; b) horizontal holes; c) vertical holes

Source: NBR 15270-3

For Bauer (2011), they are blocks manufactured with raw material (clay) in a well-defined production line, with preparation of the raw material in equipment such as deaggregators, homogenisers and rolling mills, consisting of a raw material of higher quality than that used in the manufacture of common bricks, and are molded in marombas leaving the mouthpiece (matrix) in continuous dies, where they are cut into the desired sizes in terms of their length. It turns out that the variety of matrices on the market is very large, and as a consequence the types of blocks, with variations in the textures of the faces of the blocks, the quantity and type of holes, the thickness of the walls and also the dimensions, which ends up limiting the engineering professional's domain over this type of product.

3. Materials and method

The methodology adopted is a bibliographic survey held on academic google and CAPES journal portal, admitting publications up to 2020, on the application of materials used in the manufacture of ceramic bricks, aiming to show its points such as quality, economy, sustainability and its main characteristics.

According to the theme of the work and the doubts about this theme, we sought to analyze reading the titles and abstracts in order to verify the choice of the article.

4. Results and Discussion

According to a bibliographical survey carried out in this researched, the work of three authors on the incorporation of different recyclable materials as sources and compositions to obtain a mixture that contributes to the improvement of the ceramic mass for the production of bricks was chosen for analysis in this bibliographical research . Among these investigated materials, the following stand out: granite sawdust waste (Almeira, 2015), ceramic tile waste (chamote) (Oliveira, 2015) and cellulose fibers from the recycling of cement bags (Ancelmo, 2015).

According to Almeida (2015), in his study with granite sawdust, he used clay basic mass formulations with the addition of granite (0%, 5%, 10%, 15%, 20%) and found that the results showed that the use of granite waste in the red ceramic industry is a viable alternative for increasing the technical quality of the ceramic sealing product and increasing the environmental quality. The use of granite in ceramic production, in addition to contributing to the quality of the environment, thus reducing the environmental impacts that may be caused by this residue, presented the results within the standards established by current legislation.

According to Oliveira (2015), the clays used in the process were purchased from a ceramic industry located in Cerâmica Cil, in the municipality of Teresina-PI and the waste collection was carried out in a specific area for disposal from a tile industry. and ceramic blocks in rural Piauí. The grog was reduced to its granulometry in a hammer mill with a 4 mm diameter grate. The clays were classified as red clay, gray clay and black clay with addition of grog to the clay base mass 0%, 5%, 10%, 15%, 20%, for the conclusions of the studies by Oliveira (2015) it was observed that the increase in strength was observed at all levels studied. The highest result in relation to TRF after firing was presented in the formulation of 5% chamotte at 1000 ºC, what may be associated with the formation of the spinel crystalline phase. It was also observed that all formulations exceeded the minimum strength for ceramic blocks by NBR15270-1/2005. The results showed that the use of grog in the production of structural ceramics is a viable alternative for increasing the technical quality of the structural ceramic product and increasing the environmental quality because the reuse of this waste reduces the environmental impact caused by its industries sector.

For the study carried out by Ancelmo (2015) the formulations of ceramic masses were made with contents of 0%, 3%. 6%, 10% and 15% by weight of cellulose fibers. The replacement of clay by cellulose fiber residue significantly increased the green resistance of the products, providing better dimensional stability in ceramic pieces; Through the waste preparation procedure, its economic viability of use was observed, because through simple processing and without the addition of chemical products, fibers with a structure suitable for incorporation are obtained; Due to the possibility of incorporation and consequent positive increase in the technological properties of the tile and block formulations, the environmental feasibility is verified, since a more efficient destination of the incorporated waste was observed.

5. Conclusion

According to the conclusions found in analysis 01 and analysis 02 and analysis 03 during this study, benefits were presented for the production and application of ceramic bricks with the addition of recyclable materials, as their advantages go beyond promoting sustainability, they provide improvement in quality and economy of the construction process. Furthermore, knowledge about the sustainability process in the ceramic industry can encourage professionals and other interested parties to achieve excellent results, reducing waste and the time needed to carry out activities. These results can support new proposals to encourage these actions, and also enable the creation of a new research showing the advantages of producing a quality product and encouraging the growth of brick production with recyclable materials.

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