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Analysis of the formulations of ceramic masses for the production of tiles and bricks: a bibliographic review

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Abstract

Directing attention to the production process of ceramic tiles and bricks, the importance of the ceramic sector is observed along with studies that seek improvements and positive interventions, in order to leverage the growth of the national pottery-ceramic sector. This work proposes to carry out a bibliographic review with a descriptive and informative approach, where the elaboration procedure took place through searches for scientific literature, having as descriptors: Analysis of the formulations of ceramic masses aiming at an improvement in the quality of the final product.

Keywords: Ceramic Pastes; Tiles and Bricks; Red Ceramics.

1. Introduction

Common clays are the main raw materials used in the red ceramic manufacturing process. This in turn originates from modifications of minerals in the source rock by the action of rainwater, aided by acids from the decomposition of plant remains. Although clays are found on almost the entire surface of the earth, their properties vary significantly depending on where they are found. Some can be used as they are extracted, while others must be purified and mixed to become moldable (CHRISPIM et al, 2010).

Open pit extraction is applied to most ceramic raw materials such as: taguá, clays from floodplains, etc. Among the methods, for both, the entry and exit location for trucks, excavators and other equipment must be provided. Brazil has important deposits of industrial minerals for ceramic use, whose production is mainly concentrated in the Southeast and South regions, where the largest ceramic centers in the country are located. However, other regions have shown some development of this industry, especially the Northeast, mainly due to the existence of raw materials, viable energy and a developing consumer market (SKORONSKI et al., 2015).

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, covering material, white ceramic (tableware, sanitary ware, electrical insulation, artistic ceramics), refractory materials, thermal insulation, tapes and dyes, abrasives, glass, cement, lime and advanced ceramics (PRADO, 2013).

Throughout the evolution of the world, ceramics has always been present, its manufacture dates back to antiquity in all regions and cultures. This has artisanal and industrial prominence, the abundant availability of raw material, makes it increasingly popular, with a diversification and direction in its industrialization (BAUER, 2011).

According to the Brazilian Ceramics Association (ABCERAM), structural ceramics comprise expanded clay, bricks, blocks, hollow elements, slabs, tiles and ceramic tubes, with the finished products predominantly reddish in color. And it is this last feature that makes the term red ceramic rather than structural ceramic common. (ABCERAM, 2014). The artisanal tile and brick industry is directly related to the construction of houses and buildings. The manufacture of oven-baked tiles and red brick (septum and tiles) has remained substantially unchanged since ancient times (VILLANUEVA et al., 2015).

The products manufactured by this industry are intended for the civil construction sector, and are widely used in small, medium and large-scale works. Its main applications are: structural and sealing. When structural are related to weight bearing, used in small constructions or structural masonry works. If used in the sealing function, it is normally applied in building and large constructions. They are listed as: solid and perforated bricks (in different sizes), tiles of different models, ceramic sealing and structural blocks, ceiling and floor slabs, hollow elements and floor tiles (INT, 2012).

Common clay is a basic raw material for the structural ceramic sector, more than one type is usually extracted. The extraction can be done underground or in the open (main extraction applied) and the following factors must be observed: daily amount of extraction; pre-treatment of the extracted material and its natural consistency; disposal of the material in the deposit (SOARES 2008).

The formulation of the structural ceramic mass, in general, is done empirically, with an ideal composition of plasticity and fusibility, to provide good workability and mechanical resistance to firing. The preparation of the dough is usually done by mixing a “fat” clay, which is characterized by high plasticity and fine granulometry; with a “lean” clay, less plastic with coarse granulometry. Subsequently, the mass is moistened to an average content of 20% and homogenized, to then form the ceramic products (SOARES 2008).

The objective of clay and mass preparation is to always obtain a homogeneous mixture, with constant characteristics and adequate humidity for the particular forming method used. The higher the quality of the block or tile required, the greater the control over the various stages of preparation and only through continuous control can quality be assured and maintained (BASTOS, 2003).

Regardless of the system used in production, the manufacture of any ceramic product starts with a mixture of raw materials, called “mass”, which undergoes several physicochemical transformations until reaching the properties necessary for the finished product (NECKEL, 2008).

The composition of the mass must be chosen according to the characteristics of the ceramic piece to be obtained, and the manufacturing process to be used. Therefore, the quality of the product will totally depend on the chemical composition of the dough and its processing. In general, a putty is ideal for the manufacture of a ceramic product when it meets a number of conditions:

• The relationship between plastic materials (mainly clays) and non-plastic materials must be such that it gives the ceramic mass the plasticity necessary to carry out an adequate molding, and the shaped part has sufficient mechanical strength, in green and dry;

• If the preparation is carried out wet, it must be easily deflocculable;

• The ceramic mass must have an adequate chemical and mineralogical composition, so that the physical-chemical transformations that occur in the firing process give the finished product the desired characteristics (dilation coefficient, mechanical strength, porosity, etc.). Likewise, the dough must be as insensitive as possible to variations in firing temperature, within certain limits (BARBA, 2002).

Therefore, this article aims, through a bibliographic review, to assist in the choice and indication of ceramic masses, analyzing the improvements in the properties of the products, in the reduction of the environmental impact and in the optimization of the production observing benefits that can be generated in the choice of them.

2. Methodology

For the development of this work, works already completed were analyzed through bibliographic research. Data collection was carried out on academic google and CAPES journals portal admitting publications until 2020. The bibliographic survey was carried out seeking published studies on ceramic mass formulations for the production of red ceramic tiles and bricks. After the initial search, articles that had no relevance to the theme were removed. After that, a reading of the abstracts was started to verify if the consulted work is of interest for the work to be developed, followed by a detailed reading to select the studies that are directly related to the research object.

3. Results

Gobis and Campanatti (2012), define Quality Control as a set of operations, techniques or programs, whose purpose is to obtain products that meet the required quality standards, thus promoting the elimination of the causes of unsatisfactory results in all stages of the production process to achieve economic efficiency. Research carried out on the preparation of clay and ceramic masses from Brazilian regions and published by Macêdo et al. (2005), Oliveira (2015), Gouveia (2008), Junior (2015), Vieira et al. (2006) and Moraes et al. (2016) the results found in these publications are presented here, specifically regarding the improvement in the production of new formulations of ceramic masses to always obtain a homogeneous mixture, with constant characteristics and adequate humidity that seeks quality of the raw material for production. of ceramic tiles and bricks.

Macêdo et al. (2005) presented studies and results of laboratory tests, through which the objective was to evaluate two types of clays used in a red ceramic industry in the state of Rio Grande do Norte. In the raw material preparation stage, after natural drying and in an oven (110 ˚C → 5 ˚C), the selected clays, called A1 and A2, were crushed until passing through the ABNT No. 35 sieve. formulations were made by mixing the two clays with different percentages, as Table 1.

Table 1 - Formulations used for clays A1 and A2 (% by weight)

Formulation	THE (%)	B (%)	Ç (%)	D (%)	AND (%)	F (%)	G (%)
clay 1	0.0	25.0	33.5	50.0	66.5	75.0	100.0
clay 2	100.0	75.0	66.5	50.0	33.5	25.0	0.0

Source: Macêdo (2005).

After carrying out the chemical and mineralogical tests and determining the physical-mechanical properties of the specimens of the clays studied by Macêdo et al. (2005) concluded that sample A1 is an albite clay. While sample A2 is an illite clay. While the tensile strength, the bending suffered an increase until the formulation “E” decreasing afterwards for the formulations “F” and “G”. After the results obtained, the “E” formulation is the most suitable for the manufacture of ceramic tiles.

The methodology of the work by Oliveira (2015), consists of the addition of ceramic tile residues (chamote) in the formulation of mass for ceramic blocks, the clays used in the process were classified as Red Clay, Gray Clay and Black Clay. The collection of the residue (chamote) was carried out in a specific area for disposal of an industry of tiles and ceramic blocks in rural Piauí. The chamotte was reduced to its granulometry in a hammer mill with a grid of 4 mm in diameter. The formulations of the ceramic masses were according to the insertion of chamotte in the basic mass. Formulation M0 is the standard composition of the mixture of red, gray and black clays without the addition of chamotte. The formulations M5, M10, M15 and M20, were inserted the chamotte, in the basic mass of the clays with the respective proportions
by weight of 5%, 10%, 15% and 20%.

Table 2 - Formulation of the dough in different clay and chamotte contents

Formulation of the masses	Concentration by weight %			
	Clays used			Chamote
	AV	B.C	AP	
M0	33.00	33.00	34.00	0
M5	31.60	31.70	31.70	5
M10	30.00	30.00	30.00	10
M15	28.30	28.30	28.40	15
M20	26.60	26.70	26.70	20

Source: Oliveira (2015).

After carrying out the laboratory tests, Oliveira (2005) concluded that the resistance increased in all the levels studied. The highest result in relation to TRF after firing was presented in the formulation of 5% chamotte at 1000 °C firing, which 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 chamotte in the production of structural ceramics is a viable alternative for increasing the technical quality of the structural ceramic product. and increasing environmental quality.
Gouveia (2008) also used chamotte in his research, using clay and chamotte raw materials from a Ceramic Industry in Petrolina - GO. The chamotte was obtained from the disposal of ceramic blocks burned at a temperature of approximately 800oC and crushed in a ball mill. Four compositions with a mixture of clay and chamotte were then elaborated. The 0CH formulation is the standard composition that will be used, as shown in Table 3.

Table 3 - Compositions to be investigated

Matter Cousin	Composition (%)				
	0CH	5CH	10 CH	15CH	20CH
Clay	100	95	90	85	80

Chamote	0	5	10	15	20

Source: Gouveia (2008).

The mechanical strength of the specimens obtained increased as a function of the firing temperature. However, all compositions with addition presented values lower than the standard mass, for all temperatures. With the exception of the addition of 10%. Among the compositions studied, the addition of chamotte, in the proportion of 10%, was the most satisfactory, since it met all the physical-chemical parameters and determined technological properties.

Another interesting study carried out by Junior (2015), in which he simulated clay formulations for use in the manufacture of bricks, taking as a reference the basic mass currently used by the industry through the application of statistical design, expanding the universe of possibilities, without compromising quality. of the final product, from the statistical design. The three clays used by an industry in Teresina were chosen: buriti, banana and taguá Mafrense clays. In this work, these clays were identified, respectively, as yellow (A), black (B) and taguá mafrense (C). The experimental formulations of the ceramic masses were made with the contents shown in Table 4.

Table 4: Formulations in different clay contents

Formulations (F)	Clay A (%)	Clay B (%)	Clay C (%)
MB (F0)	25	25	50
F1	0	100	0
F2	100	0	0
F3	0	0	100
F4	50	50	0
F5	0	50	50
F6	50	0	50
F7	33.33	33.33	33.33

Source: Junior (2015)

Junior (2015), used the statistical design for the results obtained in the tests of water absorption and rupture tension after firing, which are the parameters that classify the quality of the final product (NBR 15270). From them, it was possible to generate regression equations, correlating the constituent proportions in the compositions with the analyzed parameters, choosing the equations that presented statistical significance at the 97% confidence level. In the representation of the response value adjustments for the simulated formulations from clays A, B and C, linear and quadratic models were used. The application of the statistical design method makes it possible to obtain a satisfactory result of the desired technological properties with a large margin of safety.

Vieira et al. (2006), present a comparative study of the replacement of sand by fine gneiss in ceramic mass for tiles. The work by Vieira et al. (2006) studied the replacement of sand by a fine-grained gneiss, taken as a residue in the beneficiation process of this in a red ceramic mass used for the manufacture of tiles, two plastic clays were used, sand and fine gneiss. Plastic clays are called yellow clay and black clay, which together with the sand, are constituents of the ceramic mass used to manufacture tiles by an industry in the municipality of Campos dos Goytacazes-RJ. The industrial ceramic mass, called MI, is composed of 70% by weight of yellow clay, 20% of black clay and 10% of sand. A ceramic mass was prepared from the MI mass, 10% by weight of the quartz sand replaced by fine gneiss, obtained in the form of mud from the settling tanks used to treat the effluent generated at the time of cutting the slabs of a variety of Miracema stone. The specimens were prepared by uniaxial pressing for firing in a laboratory oven at temperatures of 850, 950 and 1050°C to determine the properties: plasticity, linear shrinkage, water absorption and flexural tensile strength. According to Vieira et al. (2006), the use of fine gneiss did not change the workability of the industrial ceramic mass and, due to its fine granulometry compared to sand, it increased the mechanical strength of the ceramic at all investigated temperatures. At the temperature of 1050°C, the melting power of the residue was quite pronounced, dramatically reducing water absorption and significantly increasing the mechanical strength and linear shrinkage of the ceramic. The results showed that fine gneiss can be easily used in the composition of red ceramic mass.

Moraes et al. (2016) in studies carried out, presented the possibility of environmentally correct destination of the lamp glass incorporating red ceramic, with the objective of evaluating the effect of using 30% by mass of a fluorescent lamp glass residue in the form of powder, decontaminated from Mercury. The results indicated that this residue significantly improves the physical and mechanical properties of red ceramic. Regarding the environmental assessment, the fluorescent lamp glass does not change the eventual classification of the ceramic when it becomes a discarded material. The use of 30% by mass of the residue in a mixture with clays provided a 35.1% reduction in the water absorption of the tiles and an increase of 91.2% in the flexural rupture load. Also according to Moraes et al. (2016) environmental tests showed that ceramics with 30% residue present a fluoride value, in the solubilization test, above the maximum value stipulated by standard, in addition to Al, also above the standard value for tiles without residue, therefore, ceramics without residue and ceramics with 30% residue would be classified as non-hazardous waste when discarded. The studies by Moraes et al. (2016) points out that the investigated residue has potential use in red ceramic, which can still be considered as an environmentally correct alternative for recycling. therefore, ceramics without residue and ceramics with 30% residue would be classified as non-hazardous waste when discarded. The studies by Moraes et al. (2016) points out that the investigated residue has potential use in red ceramic, which can still be considered as an environmentally correct alternative for recycling. therefore, ceramics without residue and ceramics with 30% residue would be classified as non-hazardous waste when discarded. The studies by Moraes et al. (2016) points out that the investigated residue has potential use in red ceramic, which can still be considered as an environmentally correct alternative for recycling.

3.1 Critical analysis

The use of residues as raw material for making ceramic masses has spread among researchers, in view of the problem that involves the indiscriminate generation of residues, specifically industrial residues. The volume generated and the difficulty in giving an adequate destination results in environmental pollution, silting of rivers, alteration of soil conditions. It is extremely important to look for viable alternatives for the destination of these materials. Even with a significant number of researches involving the theme of industrial waste, few actually have technical and economic feasibility, evidencing the need for further investigation. What is observed is the difficulty in evaluating the behavior of these materials, since the same type of waste can present different constitutions depending on the region of origin of the material. Possibly if complementary research were carried out on the same application for a given waste, that is, a more in-depth assessment of the behavior of the waste for a given application, thus ensuring that the proposed alternative would present technical feasibility, presenting the possibility of these wastes being reused in the manufacture of new materials, mainly in the area of civil construction. It would be coherent, therefore, for researchers to seek not only to propose a use for the waste, but rather that, following the proposal of sustainable development, they also combine reuse with more efficient products, therefore the use of waste for the production of construction materials is still cannot be considered a technological innovation, due to the lack of a broader investigation, mainly with regard to the durability of the final product, that is, its long-term performance.

4. Conclusion

From this work it is observed that there are different ways of using ceramic masses in the production process for the ceramic industry. Confirming that they offer financial benefits for civil construction, by enabling the use of a different constructive technique from the conventional one, resulting in the economy of materials and sustainable labor. The analyzed researches present satisfactory results for the scientific community, point out that the use of alternative aggregate generally increases the resistance of the final product. It can be seen that the literature also focuses on the investigation of some of the properties related to burning with promising results, however, further studies are required.

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