ISSN 2347 - 3983
Volume 8. No. 8, August 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter56882020.pdf
https://doi.org/10.30534/ijeter/2020/56882020

Waste from ceramic bricks, as a raw material for the production of restoration materials

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ABSTRACT

This article is devoted to the study of the properties of waste ceramic bricks as technogenic mineral raw materials for reuse in the production of wall materials.The article describes how the production of ceramic bricks allows you to destroy industrial waste in large quantities and using traditional technologies and equipment. The works prove the possibility of using various man-made materials in the production of ceramic bricks as an additive, and in some compositions as the main raw material, replacing partially or completely non-renewable resources of clay rocks. The large volume of production of ceramic bricks allows you to dispose of industrial waste in significant quantities and a wide range of their composition using traditional technology and hardware. The obtained results indicate the possibility of using brick fighting in the current technology of ceramic bricks of the M125, M 150 brand with a content of up to 30 wt of brick powder in a two-component charge. % at a firing temperature of up to 950 °C, which meets regulatory requirements. Thus, as a result of the experiment, the possibility of using the waste of ceramic bricks as a desiccant was established. This technogenic raw material is recommended after appropriate grinding.

Key words: ceramic bricks, industrial waste, raw material composition, clay, restoration materials

1.INTRODUCTION

It is known that the mineral resource base is being exhausted with increasing rates of production and is insufficient to meet the needs for mineral resources, which determines the need to involve technogenic materials in the production cycle [1–5]. At the same time, the production of ceramic bricks has great potential for using technogenic raw materials [6]. In [2,5], the possibility of using various technogenic materials in the production of ceramic bricks as an additive, and in some compositions as the main raw material[1], replacing partially or completely non-renewable resources of clay rocks, was proved. A large volume of production of ceramic bricks allows the disposal of industrial waste in significant quantities and a wide range of their composition using traditional technology and equipment. In addition, the creation of raw compositions using technogenic materials as an additive is one of the ways to expand the use of low-grade clay rocks, improve technical properties and lower the cost of ceramic bricks. From the point of view of rational environmental management, the breakage of ceramic bricks is an underutilized raw material for construction purposes, capable of providing the ceramic industry with high-quality thinning supplements like chamotte. It is known [7] that chamotte is one of the highest quality clay cleaners. Fireclay, unlike other scrubbers, does not reduce the refractoriness of the ceramic mass, but is an expensive material, and therefore it is not used for the manufacture of ceramic bricks.

The production of ceramic bricks in the conditions of the Republic of Uzbekistan is accompanied by the formation of a series of waste, the issue of recycling of which is still challenging. Among these wastes is the breakage of ceramic bricks and slag, the amount of which varies between 10-15% and 8-12%, respectively. Up to now, they are mainly taken to landfills for solid household waste, or they are stored in special places. Moreover, not only do landfill volumes increase significantly, mineral raw materials are also irretrievably lost, whose resources are limited in the Khorezm region. The present work is devoted to the study of the properties of ceramic brick waste as technogenic mineral raw materials for reuse in the production of wall materials. The relevance of solving this problem is due, on the one hand, to environmental problems of reducing the resource consumption of wall materials, and on the other, to issues of socio-economic development of the region.In our studies, a ceramic brick breakage was used, which is formed as a waste in the production of ceramic brick from loess like loam.

2.MATERIALS AND METHODS

The investigated waste was considered as a thinning additive in the composition of the ceramic mass to obtain ceramic bricks. The main raw materials used were clay-loess-like loams of the Gavukkul deposit of the Khiva region of the Khorezm region. The feedstock was tested in accordance with the requirements of [8] and regulatory procedures [9]. According to the physical-mechanicalproperties, determined by the number of ductility and the refractoriness index, they relate to medium-plastic and low-melting clay raw materials, and according to particle size distribution to low and medium dispersed ones. According to the mineral composition, the samples of clay rocks studied in the experiment are polymineral, mainly montmorillonite from clay. By chemical composition, they meet the requirements of Sate standard 32026-2012 and State standard 9169-75 for raw materials for the ceramic industry. Experimental studies in the work included the development of the composition of the raw material mixture and the manufacture of ceramic crock samples. The compositions of ceramic masses were developed using methods of building materials science and mathematical modeling. Raw materials, mixtures, samples were prepared according to the standard method [10]. At the preparation stage, the breakage was crushed by dry grinding in a ball mill to a fineness of grinding with a residue on sieve No. 008 of not more than 5 mass %. Sifted on a sieve No. 008 brick powder (bulk density $pH = 1256\ kg / m^3$) in theamount of 5–35 mass % was mixed with loess-like loam until a homogeneous mass. The raw material mixture was closed with water until a plastic dough was formed. Laboratory samples in the form of a cube measuring 50 × 50 × 50 mm were made from the prepared ceramic mass by plastic molding. The prepared samples were kept at a temperature of (25 ± 5) °C for 1 day. Samples were dried in an oven for 3-5 hours at a temperature of 120 °C. Samples were fired in a muffle furnace of the brand SNOL 6.7 / 1100. The firing mode was established taking into account the component composition of the raw material charge. For the studied compositions of the raw material charge in the selected ranges of variation of the mass fraction of the powder of the brick fight, the maximum firing temperature was determined within 900–950 °C. The quality assessment of samples made in laboratory conditions was carried out in accordance with regulatory requirements [11] by indicators: water absorption, average density, volumetric air and fire shrinkage [12], mechanical compressive strength [12], thermal conductivity coefficient [13], medium strength grade samples. Samples were tested in the laboratory. When studying the relationship between the content of brick breakage powder in the composition of the raw material charge and the main physical-mechanical characteristics of ceramic shard samples (water absorption, average density, volumetric air and fire shrinkage, thermal conductivity, compressive strength), the linear regression method was used [14]. The degree of nonlinearity of the considered dependences was established by determining the value of the determination coefficient R2 when approximating the parameters i (water absorption, average density, volume shrinkage, thermal conductivity, tensile strength at compression) the linear regression method was used [14]. The degree of nonlinearity of the considered dependences was established by determining the value of the determination coefficient R2 when approximating the parameters i (water absorption, average density, volume shrinkage, thermal conductivity, compressive strength) by a linear model(1)

$$y = b_0 + b_1 x \qquad (1)$$

The model was built on the basis of the results of an actual experiment and analytically describes the dependences obtained in experiments. The high value of the coefficient R2 for the dependences of the determined indicators on the content of brick breakage powder in the mixture is due to the almost linear nature.

The influence of additives such as calcite, dolomite and sodium chloride on the mineralogical–textural and physical–mechanical behavior of solid bricks intended for use as new materials in the restoration of historical buildings is studied The behavioral differences between specimens with and without carbonates can be explained by the different evolution of texture and mineralogical composition developed during the firing process. Carbonates are shown to result in bricks with different mineralogy, depending on firing, but with a stable microstructure within a wide range of temperatures (800–1000 °C). This may be an advantage when manufacturing pottery but these pieces lack mechanical resistance to high temperatures. Salt partially modifies the mineralogy of the bricks, acting as a melting agent, especially at high firing temperatures, and giving rise to more resistant products which are suitable for restoration work [15].

The changes in brick porosity upon firing (700 up to 1100 °C) and its relation to the mineralogical composition are examined. Two types of raw clay with a composition representative of that used in brick-making industry were selected to manufacture the bricks: one contains notable amounts of carbonates, with a grain size of under 1 mm, and the other is predominantly quartzitic and lacking in carbonates. We demonstrate that the presence or absence of carbonates strongly influences the porosity development and, therefore, the brick texture and physical-mechanical properties. The carbonates in the raw clay promote the formation of fissures and of pores under 1 μm in size when the bricks are fired between 800 and 1000 °C. The absence of carbonates results in a continuous reduction in porosity and a significant increase in the pore fraction with a radius (*r*)>1 μm as the firing temperature rises and smaller pores coalesce. Porosity and pore size distribution results obtained from the combined use of hydric tests (HT), mercury intrusion porometry (MIP) and digital image analysis (DIA) of scanning electron microscopy photomicrographs are compared. A clear correlation between the water absorption and drying behaviour of the bricks and the porosity plus pore size distribution is observed. DIA discloses the evolution of size, shape and connectivity of macropores (*r*> 1 μm) and evidences that MIP results underestimate the macropore content. Conversely, MIP gives a good estimate of the open porosity and of the distribution of pores with *r*<1 μm. It is concluded that the combined use of these complementary techniques helps to fully characterise the pore system of bricks. These results as well as the study of the evolution of the speed of ultrasound waves vs. time yield useful information to evaluate the bricks physical–mechanical behaviour and durability. The relevance of these findings in the conservation of historic buildings is discussed [16].

3.RESULTS AND DISCUSSION

An analysis of the experimental data given, in the figure, shows that an increase in the proportion of brick powder in the mixture leads to some increase in water absorption. At the same time, the dynamics of reducing the values of general shrinkage, average density, thermal conductivity, and compressive strength of the samples are clearly traced. In accordance with regulatory documents for different types of construction products, water absorption should not exceed 20 wt. % and is a qualitative characteristic of the sintering process.

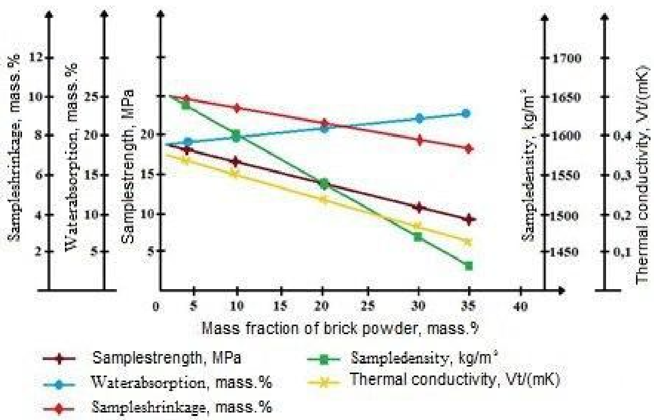

Figure 1: The main indicators of the samples

On the water absorption graph, this value is limiting when optimizing the ceramic mixture and allows determining, taking into account the obtained values of shrinkage deformations, average density, thermal conductivity and compressive strength, the rational range of changes in the content of brick powder in a two-component mixture based on low-melting clay at a certain firing temperature. The results obtained indicate the possibility of using brick fighting in the existing technology of ceramic bricks of the brand M125, M 150 with a content of brick powder of up to 30 wt. In a two-component mixture.% at a firing temperature of up to 950 ° C, which meets regulatory requirements [12].

4.CONCLUSION

In conclusion, the optimum content of crushed powder in the mass of ceramic bricks is 20-30 wt. % With an increase of more than 30 wt. % of the added additive, the compressive strength decreases below the normalized one and the water absorption of the obtained samples increases, and when its content decreases less than 10 wt. % there is no significant decrease in the coefficient of thermal conductivity. Products made from loess-like loam with an addition within the range of changes in the composition of the ceramic mass of the mass fraction of the powder of breakage of ceramic bricks have sufficient color saturation and the purity of the color tone.

Thus, as a result of the experiment, the possibilities of using ceramic brick waste as a scrubber were established. These technogenic raw materials are recommended after appropriate grinding.

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