УДК691.421 https://doi.org/10.51301/vest.su.2021.i4.23

[1]R.E. Nurlybayev, [2]M.T. Zhuginisov, [2]Zh.O. Zhumadilova, [1]Ye.S. Orynbekov, [2]E.E. Khamza, [2]I.B. Sangulova
[1]«SAVENERGY» LLP, Almaty, Kazakhstan
[2]T.Basenov Institute of Architecture and Construction, Satbayev University, Almaty, Kazakhstan
*e-mail: rusya_nre@mail.ru

INVESTIGATION OF THE EFFECT OF DIATOMITE AND BENTONITE CLAYS ON THE PROPERTIES OF LOCAL LOAM-BASED PRODUCTS

Abstract. Scientific organizations have taken an active attitude in energy- and resource-saving in buildings. New regulatory requirements for thermal protection of buildings standardized the principles of gradual reduction of thermal energy consumption for heating buildings in order to reduce the level of building energy consumption by at least 30-40% in a short time frame. Based on this, it follows that today in the world and in the country the problem of improving the thermal protective properties of building enclosing structures is one of the most urgent tasks in construction. One of the solutions to the problem of increasing the thermal protection of buildings is the use of diatomite and bentonite additives in the composition of energy-saving ceramic bricks. The main one is the design and development of new energy-and resource-saving ceramic bricks that can provide the required level of thermal protection while maintaining the previous design considerations of buildings. The current economic conditions in the country determine a new approach to choosing effective building materials for housing construction. Therefore, recently there is an urgent need for new wall materials that have energy- and resource-saving properties.

Key words: diatomite, bentonite, ceramic brick, loam, charge.

Introduction. A growing number of regulations and government programs encourage building in an environmentally friendly and energy-efficient way. The changes that happened and keep happening in thinking of investors also contribute to the search for solutions that are beneficial for people and the environment. In addition, energy-efficient and long-lasting building materials, such as ceramics, are cheaper in the long run, and houses built with them consume less energy, which saves on bills. Thus, the long-term perspective of investment, i.e. building a house, contributes to sustainable and energy-efficient construction, including from an economic point of view.

Traditionally, the term "brick" refers to a small unit of building material primarily consisting of clay. The mineral content of clay will determine the color of the brick: clays rich in iron oxide will turn reddish, and clays containing a lot of lime will have a white or yellow tint.

Ceramic tiles, clinker tiles and bricks, as well as ceramic hollow bricks for wall construction are natural and safe building materials for humans. The clay from which they are fired is a completely ecological material that does not contain chemical dyes, metals or other artificial elements. As a result, ceramic walls and roofs have provided a healthy natural microclimate for buildings made of them for hundreds of years. This feature became especially important, as it turned out that asbestos-covered roofs pose a threat to the life and health of residents.

A facade made of brick or clinker tiles, as well as a roof covered with ceramic tiles, are really durable. Their durability is designed for 100-150 years. In addition, due to their strength and resistance to adverse external factors, they practically do not require maintenance. Moreover, low absorbency means that dirt does not penetrate deep into the ceramic, and dirt from the roof and facade can simply be washed off with water. This is one of the reasons why these materials are considered eco-friendly ceramics do not need to be painted, re-poured or cleaned, so the environment is not polluted by chemicals and does not require additional costs.

In residential buildings, most of the energy (about 70%) is spent on heating. That is why building materials and structural solutions that allow you to keep heat in the house are a real aid in the fight for low bills. Energy-saving brick is one of the materials with the best thermal insulation parameters. Their properties are primarily due to their porous structure. Micropores are filled with air, which is an excellent insulator. This leads to low heat thermal transmission coefficient (U) of the entire partition. It is both a structural element and a thermal insulation element, and its thermal conductivity coefficients (λ) depend on the type of block. Moreover, bricks and other ceramic building materials, such as clay bricks and tiles, also have high heat storage parameters due to their relatively high density.

The use of materials that provide proper thermal insulation of the entire building surface is extremely important, since warm air escapes not only through the walls, but also through the roof, foundation and other structural elements.

1 Compositions and technologies of ceramic products based on natural and man- made raw materials

In TarSU named after M.Kh. Dulati research on the development of energy-and resource-saving technology of ceramic bricks based on blast furnace slags of the Karaganda Metallurgical Combine JSC "Ispat-Karmet" [1] has been conducted. Compositions of ceramic bricks containing 67- 75 (% by weight) of granulated blast furnace slag are proposed. Bentonite clay, cullet, and an alkaline additive in the form of soda were used as binding components. The compressive strength of the bricks obtained is 17-19 MPa, which corresponds to grades M 150-200.

The authors of [2] used granular phosphorus slag in ceramic brick technology. Before composing the charge, the granular phosphorus slag is subjected to co-grinding with bentonite clay in a ball mill until it passes completely through a 0.315 sieve. The ratio of phosphorus slag and bentonite clay is 4:1.67 in parts by weight. The ceramic mass includes raw materials in the following ratios (% of the weight): granular phosphorus slag – 40-60, loam – 25-40, bentonite clay – 15-20. This ceramic mass has a plasticity number P = 9.5-11 and is insensitive to drying (Kch = 0.50-0.70). The strength of ceramic bricks is 17.2-21.5 MPa.

The authors of the patent for the invention, [3] with the aim of reducing the average density ceramic bricks has developed a ceramic mass, including (% by weight): 55...65 fusible clay and 35...45 carbonate-siliceous rock with the ratio of the oxides of calcium and silicon 0,31- 0,34. The bricks manufactured on its basis have an average density of...1490 1570 kg/m^3, the porosity...38,4 41,9 %, the compressive strength of 18.6...27,5 MPa.

The author of work [4] for the production of hollow-porous products in the study of the composition of low-melting clay of the Atratyevskoe deposit with carbonaceous tripols of the Novo-Aibesinovskoe deposit (ratio 60:40) found that during firing crystalline newgrowths are built up in the form of wollastonite, and an increased proportion of glass confirmed by its high compressive and flexural strength. Solid lightweight products of the M-250 brand with a density of 1260 kg / m3 and hollow lightweight products of the M-175 brand with a density of 800 kg / m3 with a water absorption of 20% were obtained. The possibility of obtaining in the temperature range 1000-1170 ° C clinker wall products in the composition of low-melting clay of the Alekseevsky deposit with diatomite of the Inzensky deposit (the ratio of clay and diatomite is 70:30) has also been established. In this case, the content of feldspars and quartz decreases, the content of cristobalite increases significantly, the proportion of the glass phase increases significantly, accompanied by an increase in the strength of the samples in compression from 80 to 120 MPa and in bending from 27 to 50 MPa.

In the study [5], a technology for manufacturing ceramic wall products from a raw mixtureconsisting of 65 percent high-calcium fly ash, 35 percent microsilicon and 32 percent tallow pitch emulsion (over 100 %) with the addition of sodium hypochlorite in the amount of 5 (percent by weight) of pitch is proposed. Lightweight ceramic materials were obtained that meet the requirements of GOST 530-95 for wall ceramic products with an average density of 1230 kg/m^3, strength grade M100 and frost resistance F25, and thermal conductivity of 0.57 W/ (m· ^{o}C).

The study [6] investigated the possibility of obtaining a lightweight aggregate based on a composition containing 50-80 wt. % loam of the Chagan deposit and 20 ... 50 wt.%. bentonite clay of the Pogadaevskoe deposit (West Kazakhstan region). The raw materials, after being prepared, were mixed, moistened and granulated. Firing was carried out at a temperature of 1150 °C for 20 ... 30 minutes. The resulting lightweight aggregate has the following properties: bulk density 550-870 kg/m3, grade when squeezed in a cylinder 50 ... 150 MPa. It has been found that the addition of bentonite clay to the composition of loess-like loams makes it possible to transfer loams from the category of non-swelling to the category of medium-swelling clays. In addition, the presence of loess-like loams in the composition for obtaining expanded clay increases the strength of the granules 2.5 ... 3 times.

The work [7, 8] presents the results of research on the development of technology for lightweight aggregates using natural diatomite from the Utesaysky deposit of the Aktobe region. The aggregates were prepared using clinker and firing technologies. In clinker technology, Portland cement M 400 was used as a binder. The hardening of lightweight aggregate granules was carried out in humid conditions. During the firing technology, local loam, sawdust and coal were used as additives. Aggregates with a bulk density of 610-627 kg/m3 and a compressive strength in a cylinder of 2.82-3.84 MPa were obtained using clinker technology.

Aggregates with a bulk density of 532-819 kg / m3 and a compressive strength in a cylinder of 12.5-19.4 MPa were obtained using the firing technology. Received lightweight aggregates meet the requirements of GOST 32496-2013 "Porous aggregates for lightweight concrete. Technical conditions".

The article [9] studied the possibility of developing compositions of masses based on

local loam for the manufacture of conventional ceramics. To reduce the average density of effective wall products, crushed local reeds, ash slag formed from combustion of coal in domestic conditions, and natural diatomite were used as additives. Additives were introduced into the composition of the ceramic mass in an amount of 5-20%. Firing of the cylinder specimens was carried out in a muffle furnace at temperatures of 950, 1000, and 1100 ° C. With the addition of household slag, ceramic products with an average density of 1385-1410 kg / m3 and a compressive strength of 9.2-11.2 MPa were obtained. With the addition of diatomite, articles with an average density of 1438-1510 kg / m3 and a compressive strength of 8.8-10.7 MPa were obtained. In terms of density, products correspond to the conditionally effective and strength grades M 75-100.

Materials and methods. For the experiments, loam of the ALMATINSKOE field, located in the Kaskelensky region, 4-5 km south of the operating brick plant, was used as the main raw material. The loam has a plasticity number of 8.9 and is classified as low-plastic, in terms of refractoriness it is classified as a low-melting clay raw material. Loams are suitable for the manufacture of frost-resistant bricks of grades 100 and 125 by plastic pressing, which meets the requirements of GOST 530-2012 [10].

The brick produced at the plant has the M 75 grade (GOST 530-2012 "Bricks and ceramic stones" TU). The average density of bricks is 1610-1700 kg / m3. 3-5 percent of coal is added as a burn-out additive at the plant in the production of bricks.

The chemical composition of loams, (wt.%): SiO_2 - 52.49; Al_2O_3 12.2; Fe_2O_3 - 4.81; TiO_2 - 0.61; MgO 2.18; CaO 10.51; K_2O 2.32; Na_2O 1.88; SO_3 0.74; H_2O - 1.22; p.p. - 10.02.

According to X-ray phase analysis (in accordance with Figure 1), clay minerals of the loam of the Almaty deposit are represented by montmorillonite (d / n, Å - 6.44; 4.49; 3.19; 2.56; 1.673; 1.507). As impurities, they contain quartz (d / n, Å-4.25; 3.34; 2.46; 2.28; 2.12; 1.981; 1.819; 1.673; 1.542; 1.375), feldspars, represented by orthoclase (d / n, Å-4.04; 3.77; 3.19; 3.043; 2.89), and calcite is also present (d / n, Å-3.03; 2.28; 2.095; 1.911; 1.605) Content according to the chemical analysis data is 4.81, the diffractogram shows interplanar reflection characteristic of iron oxide of the hematite type. In this regard, it can be assumed that iron (III) oxide is part of hematite (d / n, Å-2.518). Figure 1 shows a diffractogram of a loam.The loam was applied after grinding and sieving through a 1 mm sieve.

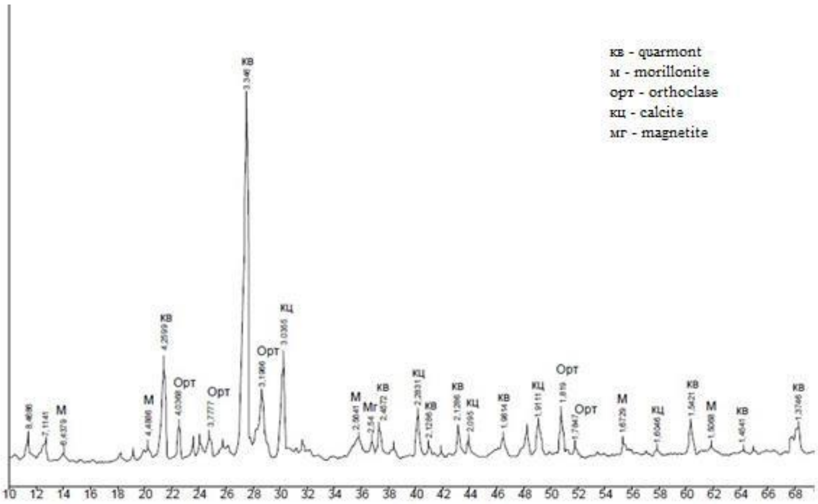

Figure 1. Diffractogram of loam The Almaty field.

Diatomite (Diatome – dissection), light, porous sedimentary rock, consisting of a wide variety of microscopically small yellowish algae, the shell of which, formed from two halves (hence the name), is impregnated with silica.

In the construction industry, diatomite has found application as a raw material for heat and sound insulation materials, as well as an additive to cements, concrete, mortars and dry mixes for various purposes [11].

Diatomites of the Utesaysky deposit are light gray in color, dense, have the following chemical composition, (wt.%): SiO2 65.88-83.65; Al2O3 8.36-14.00; Fe2O3 2.35-6.9; CaO 0.5-1.5; MgO 0.62-1.64; SO3 0.1-3.0; p.p. 4.59-12.1. Diatomite properties: true density 2200 kg /m3; bulk density 400-600 kg / m3, porosity 72-82 percent, and organogenic impurities and moisture 11 percent.

According to X-ray phase analysis, they contain β-quartz, kaolinite, montmorillonite, and magnetite. The bulk of diatomite is an amorphous substance and is not detected on the X-ray diffraction pattern. The presence of clay minerals in the diatomite composition indicates that it has plasticity, sinterability and shrinkage, that is, properties inherent in clays. Figure 2 shows a diffractogram of diatomite.

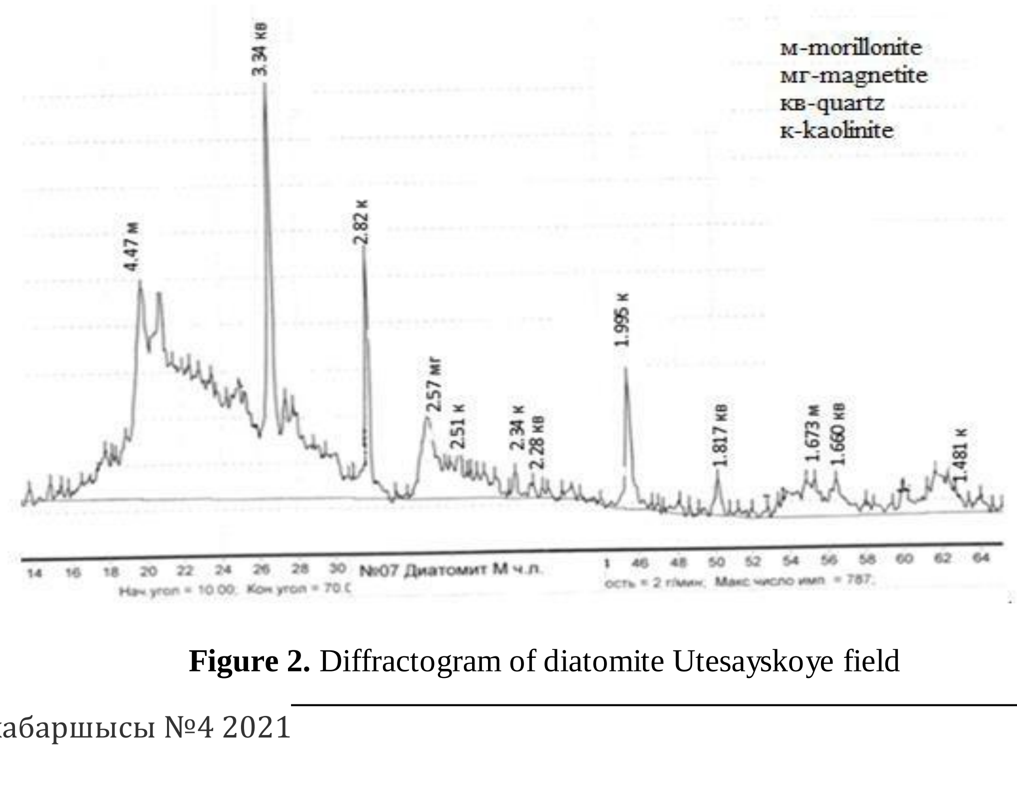

Figure 2. Diffractogram of diatomite Utesayskoye field

Diatomite was used after crushing and grinding until it passed through a 0.315 mm sieve.

After dosing, the loam and additives were thoroughly mixed, first in a dry state, then water was added in the amount required to obtain a plastic molded mass. To study the properties of products, standard cylinder samples were prepared with following dimensions: diameter 50 mm, height 50- 55 mm. The cylinders were manually molded by filling and pressing on a hydraulic press at a pressure of 2-4 kN.

The samples were dried in a ShS 80-01 SPU drying chamber at a temperature of 95-100 °C for 1-2 hours. After drying, the weight and dimensions of the samples were determined. The products were fired at temperatures of 950, 1000, and 1050 °C in a SNOL 1.6/1100 muffle furnace. The rate of temperature rise in the furnace was 5°C/min. holding at the final temperature for 1 hour.

To obtain comparative results, cylinder specimens were made on the basis of pure loam, fired at the same temperatures.

Table 1 shows the compositions of the charges and the results of determining the properties of the samples after firing at temperatures of 1000 and 1100 °C on the basis of loam without additives and the addition of diatomite.

Results. As can be seen from Table 1 and Figures 4 and 5, the amount of added diatomite noticeably affects the properties of the products. Specimens of pure loam after firing at a temperature of 1000 °C have a density of 1640 kg / m3 and a compressive strength of 10 MPa. When diatomite is added in an amount of 10 – 20%, the density decreases to 1538 – 1633 kg / m3, and the strength of the products increases to 11.7 – 14.9 MPa. The addition of diatomite in an amount of 25-30% leads to a decrease in the strength of the samples to 10.3-10.4 MPa, while the strength practically corresponds to the strength of a sample made of pure loam. The addition of diatomite in the amount of 35-50% increases the strength of the samples to 12.4-13.27 MPa, or 2.4-3.27 MPa more than that of the sample on pure loam. The average density of the samples naturally decreases with an increase in the amount of diatomite in the composition of the products. So, starting with the addition of 10% to 50% diatomite, the average density of the samples after firing at 1000 °C decreases from 1633 to 1283 kg/m3. An inexplicable fact is that the surface of samples containing 30% or more of diatomite crumbles. At the same time, with an increase in the amount of diatomite, the surface of the samples showered more intensively.

Table 1. **Charge compositions and properties of products with the addition of diatomite**

№ n/a nu mb er	Compositions	ρ., kg / m3		Compressive strength, MPa		Volume shrinkage,%		Note
		1000 ^{O}C	1100 ^{O}C	1000 ^{O}C	1100 ^{O}C	1000 ^{O}C	1100 ^{O}C	
1	Loam– 100 %.	**1640**	**1601**	**10,0**	**17,46**	**0,9**	**1,8**	Sample color light yellow
2	Loam - 90 %; diatomite 0,315 mm– 10 %.	**1633**	-	**11,7**	-	**1**	-	Sample color light yellow
3	Loam-85 %; diatomite 0,315 mm-15 %.	**1560**	-	**14,76**	-	**1,1**		Sample color light yellow
4	Loam-80 %; diatomite 0,315 mm– 20 %.	**1538**	**1525**	**14,9**	**13,24**	**1,2**	**2,3**	Sample color light yellow
5	Loam-75% diatomite 0,315 mm– 25 %.	**1471**	**-**	**10,4**	**-**	**1,3**	-	The color of the sample is light yellow with a pink tinge

6	Loam-70 %; diatomite 0,315 mm-30%	**1410**	**1439**	**10,3**	**13,27**	**1,7**	**3,5**	Sample after firing 1000 ^{O}C crumbles
7	Loam-65 %; diatomite 0,315 mm– 35 %.	**1379**	**-**	**12,8**	**-**	**2,2**	**-**	Sample after firing 1000 ^{O}C crumbles
8	Loam-60 %; diatomite 0,315 mm– 40 %.	**1377**	**1347**	**13,27**	**11,76**	**2,9**	**4,4**	Sample after firing 1000 ^{O}C crumbles
9	Loam-55 %; diatomite 0,315 mm– 45 %.	**1314**	**-**	**12,23**	**-**	**3,1**	**-**	Sample after firing 1000 ^{O}C a lot of crumbling
10	Loam-50 %; diatomite 0,315 mm-50 %.	**1283**	**1361**	**12,4**	**9,71**	**3,7**	**6,2**	Sample after firing 1000 ^{O}C a lot of crumbling. After burning at 1100^{O}C does not crumble, the color is reddish.

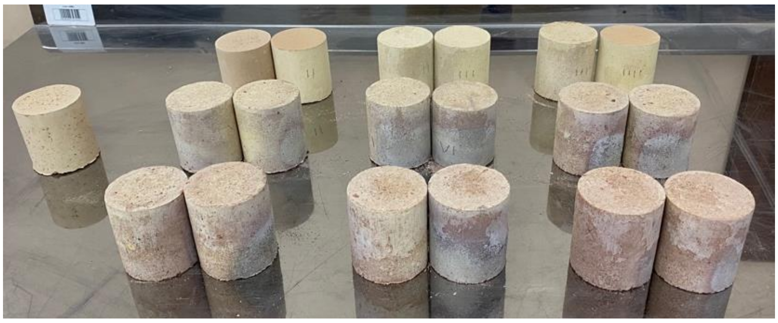

Figure 3. General view of samples with the addition of diatomite after firing at 1000 ^{O}C x 1 hour

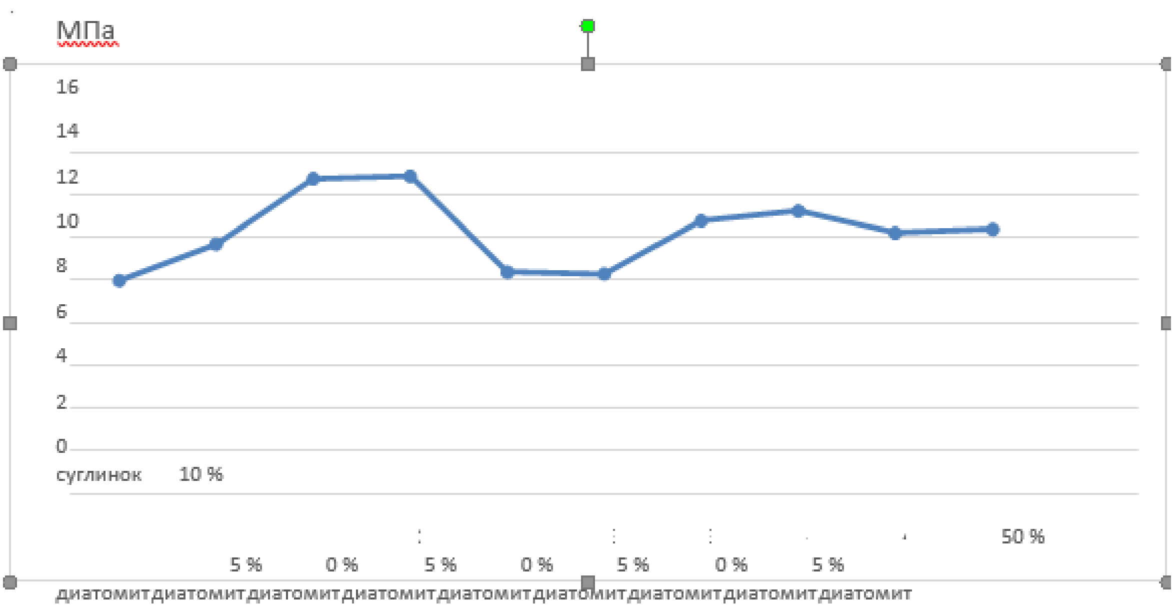

Figure 4. Dependence of the compressive strength of ceramic samples on the content of diatomite after firing at 1000 ^{O}With.

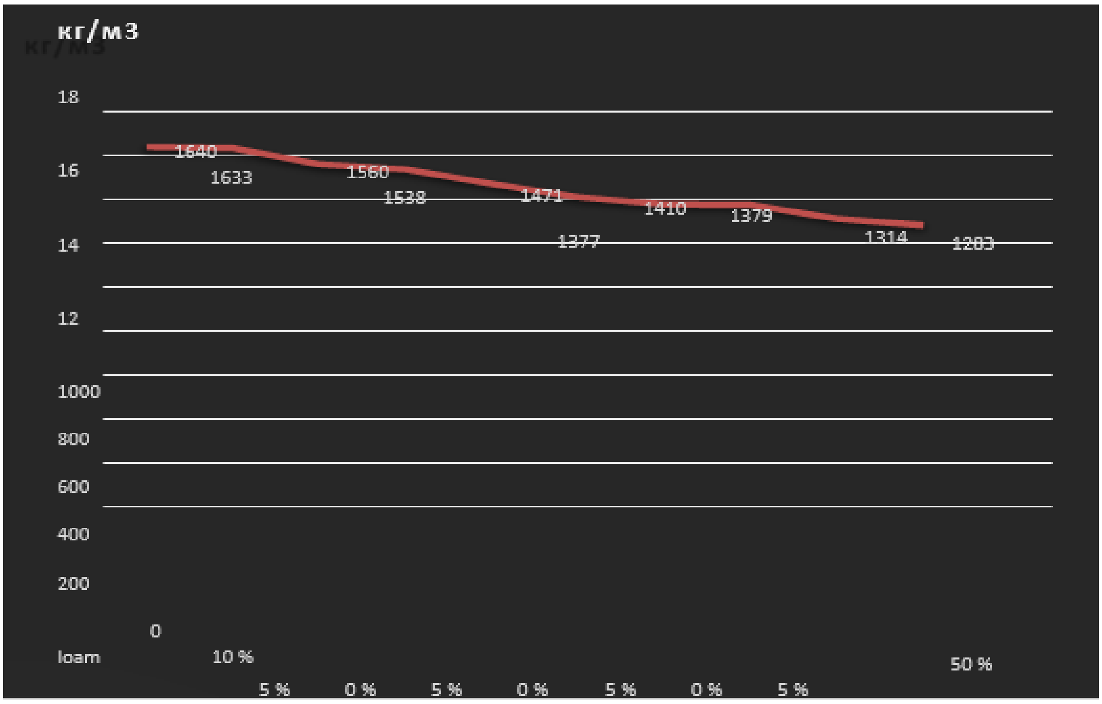

Figure 5. Dependence of the average density of ceramic samples on the content of diatomite after firing at 1000 ^{O}C

The study of the properties of samples of products based on local loam with the addition of diatomite after firing at 1000 °C showed that the addition of diatomite to the composition of loam, in general, increases the strength of product samples by 1.7 – 4.9 MPa. Samples with the addition of diatomite in an amount of 25-30% have a strength similar to that of samples based on pure loam. The natural decrease in the average density of samples with an increase in the amount of diatomite in the composition of the products, which can be explained by the low bulk density of diatomite. At the same time, the average density of the samples decreases by 184 – 534 kg/m3. As the concentration of diatomite in the ceramic mass increases, the volumetric shrinkage of the samples increases, which indicates an improvement in its sinterability.

We also studied the properties of samples with the addition of diatomite in an amount of 20, 30, 40 and 50% after firing at a temperature of 1100 °C for 1 hour. Table 1 lists their properties. Figures 6 and 7 show photographs of the samples. Figures 8 and 9 show the dependences of the strength and average density of the samples on the amount of diatomite.

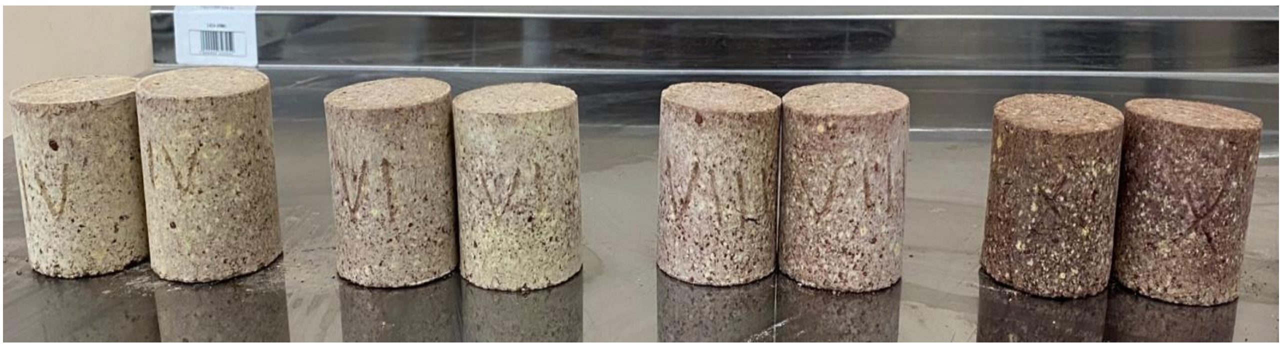

Figure 6. General view of samples with the addition of diatomite after firing at 1100 ^{O}C x 1 hour


Composition # 4 (20 % diatomaceous earth)Composition No. 6 (33.0% diatomite)


Composition No. 8 (40 % diatomite)   Composition No. 10 (50 % diatomite)

Figure 7. Appearance of standard sampleb- cylinders with diatomite addition after firing at 1100 ^{O}C x 1 hour

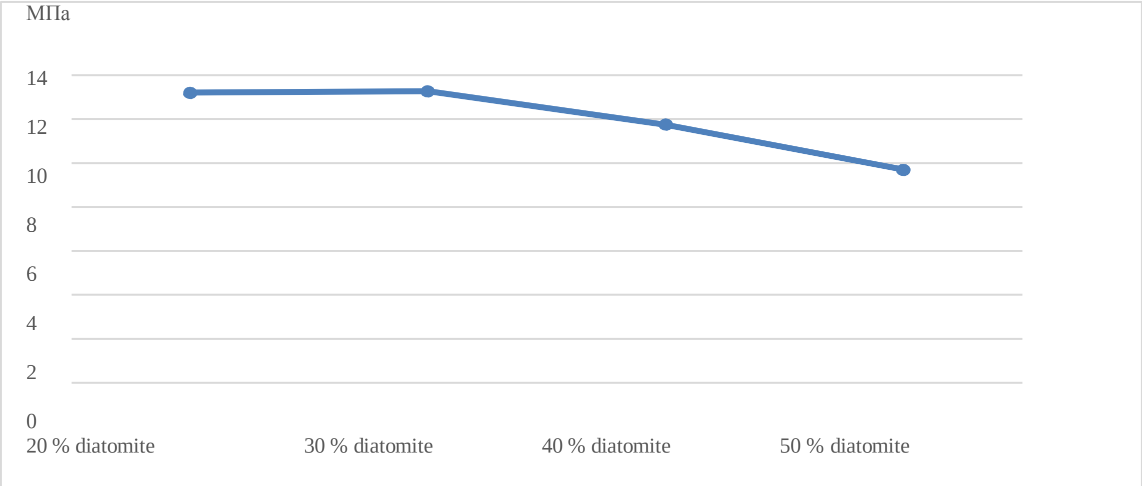

Figure 8. Dependence при of the compressive strength of ceramic samples on the content of diatomite after firing at 1100 ^{O}C

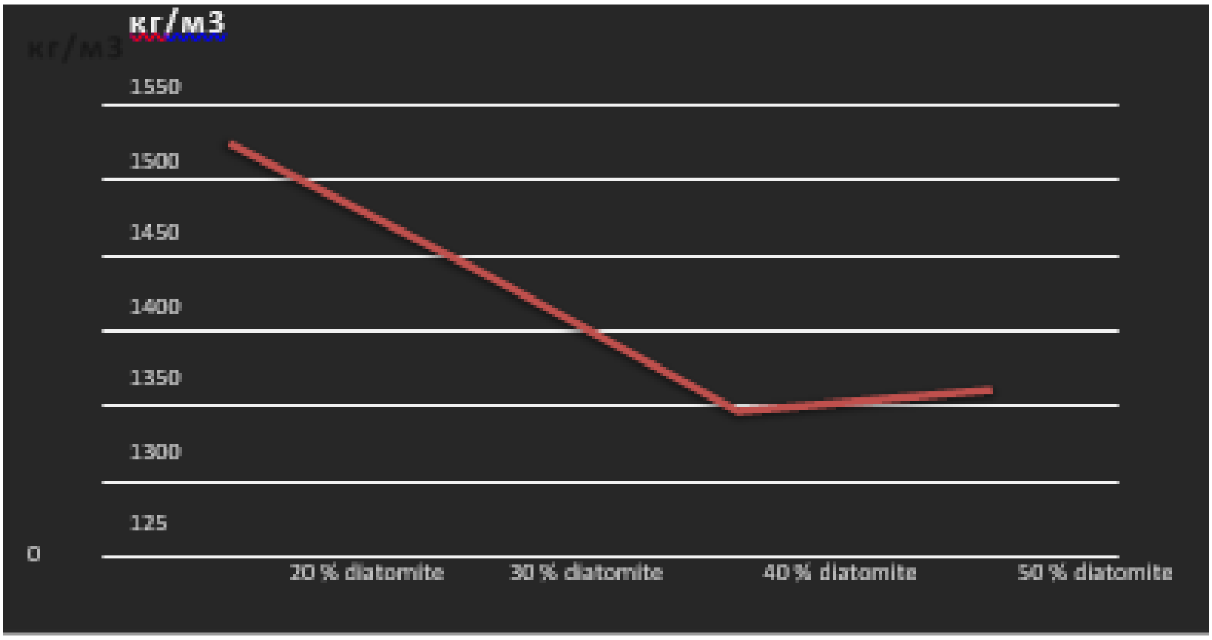

Figure 9. Dependence of the average пdensity of ceramic samples on the content of diatomite after firing at 1100 ^{O}C

As can be seen from the data in Table 1 and the graphs in Figures 7 and 8, a sample of pure loam after firing at a temperature of 1100 °C has an average density of 1601 kg/m3 and a compressive strength of 17.46 MPa. Samples containing 20 and 30% diatomite have practically the same strength of 13.24 and 13.27 MPa, while the average density of the products corresponds to the values of 1525 and 1439 kg/m3, respectively. Samples containing 40 and 50% diatomite have strengths of 11.76 and 9.71 MPa, while the average density of the products corresponds to the values of 1347 and 1361 kg/m3, respectively. The average density of the samples decreases from 1525 to 1347 kg/m3 or by 76-254 kg/m3 in comparison with the sample from pure loam. Compressive strength of products also decreases relative to the strength of a pure loam specimen by 4.19 – 7.75 MPa. After firing at 1100 °C, no sagging of the surface of the samples is observed. The volumetric shrinkage of specimens has higher values than that of specimens fired at 1000 °C, which is associated with the intensification of the sintering process of the shard. This is confirmed by the appearance and the absence of shedding of the surface of the samples. However, there is no increase in product strength indicators.

Thus, the study of the effect of diatomite additives showed that with an increase in its amount, regardless of the firing temperature, in general, there is a decrease in the values of the compressive strength and average density of the samples. From ceramic masses with a diatomite content of 15-25%, conditionally effective wall products with an average density of 1410-1560 kg/m3 and a compressive strength of 10-14 MPa can be obtained. It should be noted that the addition of diatomite even up to 50% does not lead to noticeable sintering and the production of clinker-type products. Previously, we found that the addition of 15-20% of bentonite from the Utesayskoye deposit to loam makes it possible to obtain products with a highly sintered (vitrified) shard.

In addition to diatomite, bentonite clay of the Darbazin deposit of the South Kazakhstan region was used to compose the ceramic mass, with the following chemical composition, wt. %: SiO2 - 61.51; Al2O3 + TiO2 - 16.06; Fe2O3 5.36; CaO 2.27; MgO 3.21; R2O 3.57; SO3 1.27;p.p. - 6.75. Plasticity number 37.5. According to the number of plasticity, bentonite clay belongs to highly plastic, according to its refractory properties, it is referred to as fusible. By the content of Fe2O3 - to clays with a high content of coloring oxides, and by the content of Al2O3 - to the group of acidic raw materials. Table 2 shows the charge compositions and the results of determining the properties of samples after firing at a temperature of 1000 ^{o}C and 1100 ^{O}C based on pure loam and with the addition of bentoniteclay.

Table 2. **Charge compositions and properties of products with the addition of bentonite clay**

№	Compositions	p, kg/m3^{3}		Compressive strength, MPa		Average shrinkage, % %		Note
		1000 ^{o}C	1100 ^{o}C	1000 ^{o}C	1100 ^{o}C	1000 ^{o}C	1100 ^{o}C	
1	Loam-100 %	**1640**	**1601**	**10.01**	**17.46**	0.9	1.8	Sample color light yellow
2	Loam-90 %; bentonite-10 %	**1586**	**1588**	**9.78**	**21.42**	0.1	1.8	Sample color light yellow
3	Loam-85 %; bentonite-15 %	**1580**	**1570**	**8.5**	**21.46**	0	1.9	Sample color light yellow with green tint
4	Loam-80 %; bentonite-20 %	**1600**	**1594**	**9.86**	**15.58**	0	0.6	Sample color light yellow with green tint
5	Loam-75 %; bentonite-25 %	**-**	**1604**	**-**	**11,97**		0	Small transverse cracks on the sample
6	Loam-70 %; bentonite-30 %	**-**	**1555**	**-**	**9,8**		0	Transverse cracks and swelling (small)on the
								sample at the base.

Figures 10 and 11 show photographs of cylinder samples made of pure loam and supplemented with bentonite clay.

Figure 10. General view of samples with the addition of bentonite clay after firing at 1000 ^{O}C x 1 hour

Composition # 1 (pure loam)

Composition # 2 (10% bentonite)

Composition # 2 (15% bentonite)

Composition # 2 (20% bentonite)

Figure 11. Appearance of standard sampleb- cylinders with bentonite addition бентонafter firing at 1000 ^{O}S x 1 hour

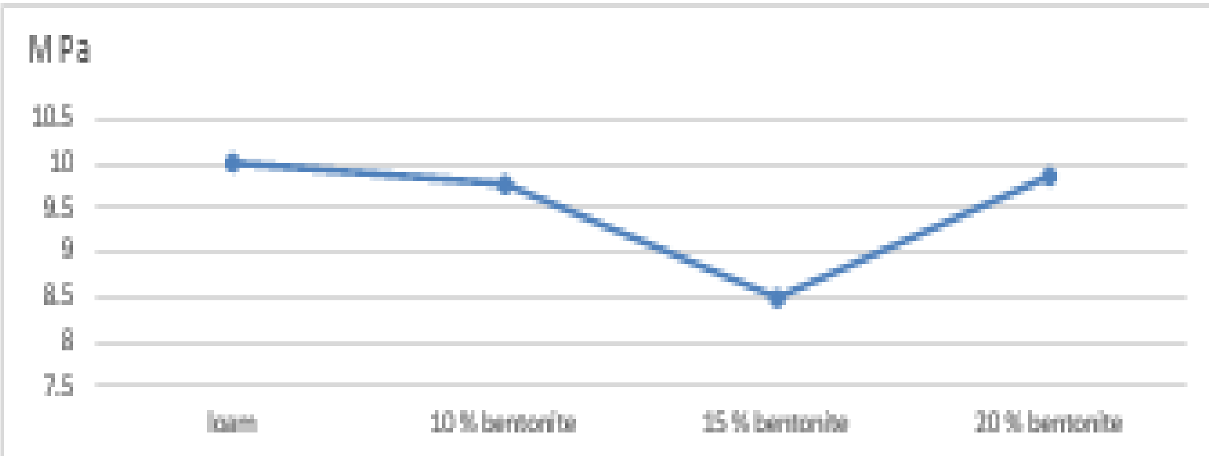

Figure 12. Dependence of the compressive strength of ceramic samples on the bentonite content after firing at 1000 ^{O}C

The results of studies on the effect of bentonite clay on the properties of loam are presented in Table 2 and in Figures 12, 13, 16 and 17. The data in Table 2 show that the addition of bentonite clay in the amount of 10, 15 and 20% reduces the average density and compressive strength of products fired at 1000 °C. At the same time, the density decreases by 40-60 kg/m3, and the strength by 0.14-1.5 MPa. The volumetric shrinkage of the samples decreases with an increase in the addition of bentonite clay to 0%. This is due to the tendency of bentonite clay to swell, i.e. when chemically bound water is removed from the structure of montmorillonite, the structural plates of the mineral spread apart, which leads to a decrease in shrinkage processes.

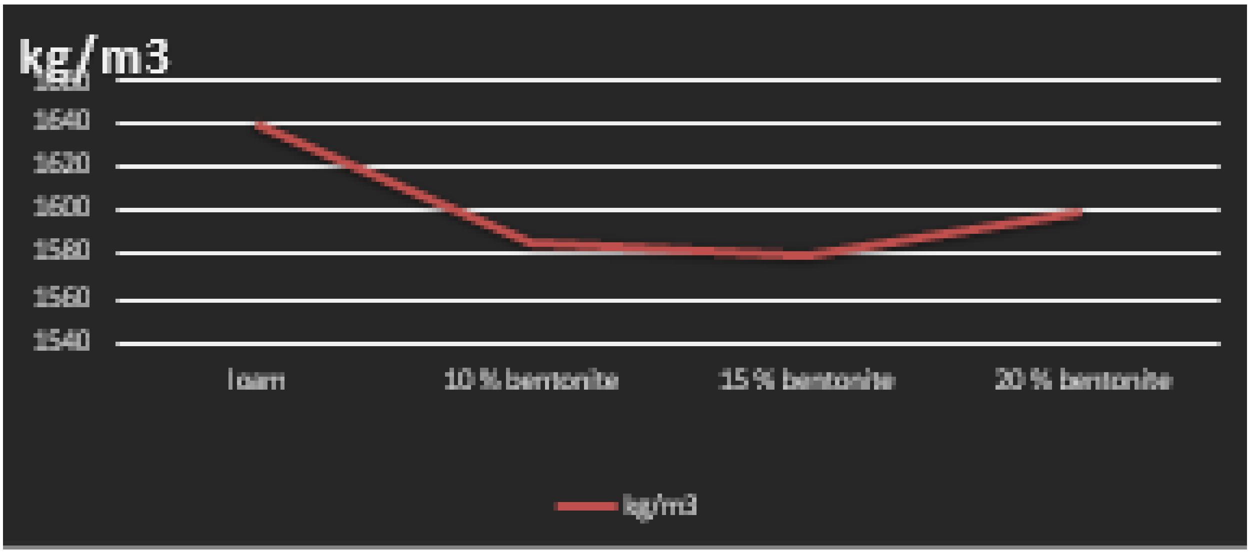

Figure 13. Dependence of the average density of ceramic samples on the bentonite content бентонafter firing at 1000 ^{O}C.

Figures 14 and 15 show photographs of samples with the addition of bentonite clay after firing at 1100 °C. Specimens containing 35, 40, 45 and 50% bentonite clay after firing have significant transverse cracks. With an increase in the amount of bentonite clay in the samples, the crack sizes become larger. The photograph shows that on samples of compositions 5 and 6, small transverse cracks are visible. Figure 15 shows photographs of samples with the addition of bentonite clay in the amount of 35 and 40%, which have significant transverse and longitudinal cracks.

Figure 14. General view of samples with the addition of bentonite clay after firing at 1100 ^{O}C x 1 hour

Figure 15. Samples with the addition of bentonite clay (35 and 40 %) after firing at 1100 ^{O}S x 1 hour

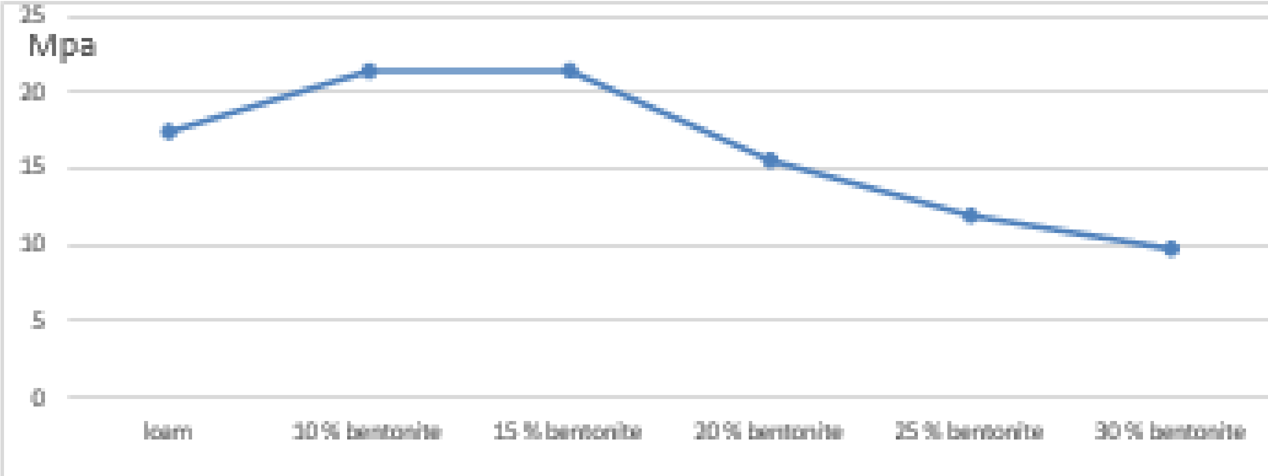

Figure 16. Dependence of the compressive strength ofceramic samples on the bentonite content after firing at 1100 ^{O}C

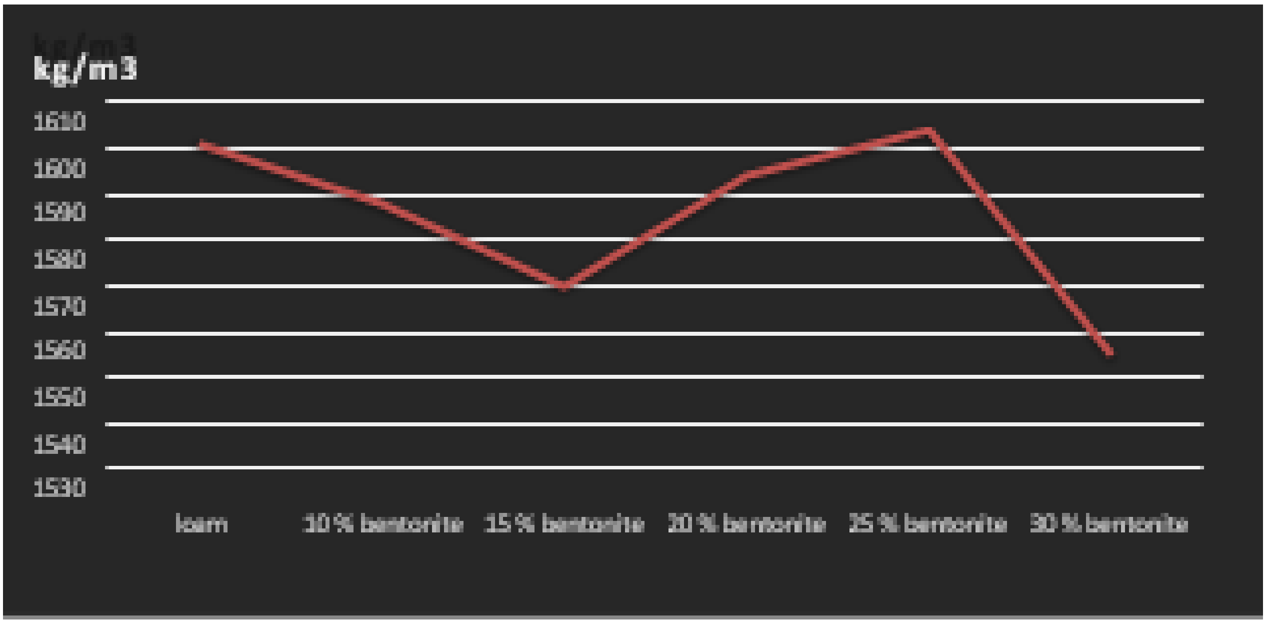

Figure 17. Dependence of the average density of ceramic samples on the bentonite content after firing at 1100 ^{O}C

The formation of cracks in samples containing 30% or more is associated with the structure of the clay component of bentonite clay. The composition of bentonite clay contains up to 70% of the mineral montmorillonite (Al2 (OH) 2) [Si4O10] · nH2O), the particle size of the mineral is less than 1 micron. When moistened, Montmorillonite swells strongly and increases in volume up to 16 times. The plasticity number of bentonite clay is more than 35, which contributes to the absorption and retention of water in large quantities. Therefore, ceramics containing more than 30% have a high water retention capacity. The main reason for the formation of transverse cracks is the structure of the mineral montmorillonite. The lamellar structure of the montmorillonite mineral, where silicate layers, the maximum distance between which is approximately 1.4 nm and are separated by layers of water molecules, the thickness of these layers can vary widely depending on the amount of mixing water to obtain a mass of working consistency. Therefore, during drying, physical removal occurs, and during firing, chemical bound water, which, in the form of steam, push the lamellar silicate layers vertically, which leads to the formation of transverse cracks.

The addition of bentonite clay in the amount of 10, 15 and 20% contributes to a certain decrease in the average density of products by 7-31 kg / m3. The compressive strength increases by 3.9 - 4 MPa with the addition of bentonite clay in an amount of 10, 15%, while the volumetric shrinkage of these products is 1.8 and 1.9%, which indicates the ongoing sintering processes. Samples with additions of 20, 25 and 30% bentonite clay have a strength of 1.87; 5.49 and 7.66 MPa, respectively, lower than that of the sample on pure loam (table 2). Starting with the addition of 20% bentonite clay, the shrinkage of the products noticeably decreases from 0.6 to 0%, which is associated with the above processes. A significant decrease in the strength of samples with 25 and 30% bentonite clay is associated with the formation of small longitudinal cracks (Figure 14).

Thus, the most optimal is the addition of bentonite clay in an amount of 10-15% to the local loam, which helps to reduce the average density and increase the compressive strength of the samples. In this case, the optimization of the properties of the products is achieved at a firing temperature of 1100 ° C, at which a rather durable ceramic shard is formed.

Conclusion. The comparison results are expressed by the ratio of the average values of the results obtained. From the table we see that the amount of diatomite in the composition of the samples affects their properties. Diatomite in the amount of 10-20% and when fired at 1000 °C in the composition reduces the density of the products and increases the strength. Diatomite in an amount of 25-30% leads to a decrease in the strength of the samples.

Also, the average density of cylinder samples is reduced by 184 - 534 kg/m3. And with an increase in the amount of diatomite in the samples, the volumetric shrinkage of the samples increases, which indicates an improvement in sintering.

Studies have shown that an increase in the amount of diatomite, regardless of the firing temperature, leads to a decrease in strength and average density. With a diatomite content of 15-25%, effective wall products with an average density of 1410-1560 kg/m3 and a compressive strength of 10-14 MPa can be obtained.

The data obtained in the study of samples with the addition of bentonite showed that it in an amount of 10, 15 and 20% reduces the average density and compressive strength of products fired at 1000 °C. Specimens containing 35, 40, 45 and 50% bentonite clay after firing at 1100 °C have significant transverse and longitudinal cracks.

The publication was prepared based on the results of research work on the topic: AP09058365 "Development of technology for high-strength clinker and energy-efficient ceramic wall products made of clay and opal-cristobalite rocks", carried out within the framework of the government order for grant financing of young scientists for the implementation of scientific and technical projects.

REFERENCES

[1] Kirgizbaev A.T. Razrabotka sostavov i tehnologiя stenovoi keramiki skorostnogo objiga na osnove domennyh şlakov. Avtoref. kand. tehn. nauk. Almaty, 2002. 20 s.

[2] Juginisov M.T., Myrzahmetov M.M., Akmalaev K. A. Razrabotka tehnologii keramicheskogo kirpicha s primeneniem fosfornogo şlaka. Trudy mejdunarodnogo foruma «İnjenernoe obrazovanie i nauka v 21 veke: Problemy i perspektivy», posvяennogo 80-leti KazNTU im. K.İ. Satpaeva. 22-24 oktяbrя 2014, T.1. S. 477- 482.

[3] Patent RF № 2176224. Keramicheskaя massa dlя izgotovleniя stenovyh izdelii, preimuestvenno, kirpicha keramicheskogo. Kl. C04B33/00, C04B33/13 Kornilov A.V.; Gonh V.M.; Şamseev A.F.; Ablяmitov P.O. Opublikovano 27.11.2001.

[4] Salahova R.A. Vysokoprochnye keramicheskie stenovye izdeliя iz legkoplavkih glinistyh i opal-kristobalitovyh porod. Dissertasiя kand. tehn. nauk. 161 s. Nauchnaя biblioteka dissertasii i avtoreferatov dısser Cat. http://www.dıssercat.com/content/vysokoprochnye-keramıcheskıe- stenovye-ızdelıya-ız-legkoplavkıkh-glınıstykh-ı-opal-krıstobalı#ıxzz4Bqp3EBNj.

[5] Maksimova S.M. Stenovye keramicheskie materialy ponijennoi srednei plotnosti na osnove

vysokokalsievoi zoly i mikrokremnezema. Avtoref. dissertasii kand. tehn. nauk. Tomsk, 2002. 29 s.

[6] Montaeva A.S., uchkin S.V., Montaev S.A. i dr. İssledovanie keramicheskoi kompozisii dlya poluchenія legkogo zapolnitelя. Materialy konferensii «Uspehi sovremennogo estestvoznanія», № 6, 2012. S.40-41.

[7] Juginisov M.T., Berikbolova A. Legkii zapolnitel na osnove diatomita // Materialy Mejdunar. nauch.- prakt. konfer., posvяennoi 120-leti Akademika K.İ. Satpaeva i 85-leti obrazovanія KazNİTU: İnnovasionnye tehnologii – klch k uspeşnomu reşeni fundamentalnyh i prikladnyh zadach v rudnom i neftegazovom sektorah ekonomiki RK. KazNİTU. – 2019. S.889-893.

[8] Juginisov M.T., Berikbolova A. Energoeffektivnyi legkii zapolnitel na osnove diatomita. // III mejdunarodnaя nauchno - prakticheskaя konferensiя. Kachestvo. Tehnologii. İnnovasii. Novosibirsk. – 2020. S.126-130.

[9] Juginisov M.T., Aldanyş B. Oblegchennaя keramika na osnove mestnogo syrя. Materialy Mejdunar. nauch.- prakt. konfer., posvяennoi 120-leti Akademika K.İ. Satpaeva i 85-leti obrazovanія KazNİTU: İnnovasionnye tehnologii – klch k uspeşnomu reşeni fundamentalnyh i prikladnyh zadach v rudnom i neftegazovom sektorah ekonomiki RK. KazNİTU, 2019.

[10] GOST 530-2012 «Kirpich i kamni keramicheskie» TU. 2012.

[11] Nemetallicheskie poleznye iskopaemye SSSR, M., 1984. – 547 s.

[1]Р.Е.Нурлыбаев*, [2]М.Т.Жугинисов, [2]Ж.О.Жумадилова, [1]Е.С.Орынбеков, [2]Е.Е.Хамза, [2]И.Б. Сангулова

[1]«SAVENERGY» ЖШС, Алматы, Қазақстан

[2]Сәулет және құрылыс институты, Satbayev University, Алматы, Қазақстан

*e-mail: rusya_nre@mail.ru

ДИАТОМИТ ПЕН БЕНТОНИТ САЗЫНЫҢ ЖЕРГІЛІКТІ САЗДАУЫТ НЕГІЗІНДЕГІ ӨНІМДЕРДІҢ ҚАСИЕТТЕРІНЕ ӘСЕРІН ЗЕРТТЕУ

Аңдатпа. Ғылыми ұйымдар ғимараттардағы энергия және ресурстарды үнемдеу мәселелері бойынша белсенді позицияға ие болды. Ғимараттарды жылудан қорғауға қойылатын жаңа нормативтік талаптар қысқа мерзім ішінде ғимараттардың энергия тұтыну деңгейін кемінде 30-40% - ға төмендету үшін ғимараттарды жылытуға арналған жылу энергиясының шығыстарын кезең-кезеңімен төмендету қағидаттарын регламенттеді. Осыны негізге ала отырып, бүгінде әлемде және елде ғимараттардың қоршау конструкцияларының жылу қорғау қасиеттерін арттыру мәселесі құрылыстағы ең өзекті міндеттердің бірі болып табылады. Ғимараттардың жылу қорғанысын арттыру мәселесін шешудің бірі-энергияны үнемдейтін керамикалық кірпіштің бөлігі ретінде диатомит пен бентонит қоспаларын қолдану. Олардың негізгілері ғимараттардың бұрынғы жобалық шешімдерін сақтай отырып, жылу қорғаудың қажетті деңгейін қамтамасыз етуге қабілетті жаңа энергия және ресурс үнемдейтін керамикалық кірпіштерді әзірлеу және игеру болып табылады. Елдегі қалыптасқан экономикалық жағдайлар Тұрғын үй құрылысы үшін тиімді құрылыс материалдарын таңдаудың жаңа тәсілін айқындап береді. Сондықтан жақында энергия және ресурстарды үнемдейтін қасиеттері бар жаңа қабырға материалдарына деген қажеттілік туындады.

Негізгі сөздер: диатомит, бентонит, керамикалық кірпіш, саздақ, шикіқұрам.

[1]Р.Е.Нурлыбаев*, [2]М.Т.Жугинисов, [2]Ж.О.Жумадилова, [1]Е.С.Орынбеков, [2]Е.Е.Хамза, [2]И.Б. Сангулова

[1]ТОО «SAVENERGY», Алматы, Казахстан

[2]Институт архитектуры и строительства им.Т.Басенова, Satbayev University, Алматы, Казахстан

*e-mail: rusya_nre@mail.ru

ИССЛЕДОВАНИЕ ВЛИЯНИЯ ДИАТОМИТА И БЕНТОНИТОВОЙ ГЛИНЫ НА СВОЙСТВА ИЗДЕЛИЙ НА ОСНОВЕ МЕСТНОГО СУГЛИНКА

Аннотация. Научные организации заняли активную позицию по вопросам энерго – и ресурсосбережения в зданиях. Новые нормативные требования к теплозащите зданий,

регламентировали принципы поэтапного снижения расходов тепловой энергии на отопление зданий с тем, чтобы короткие сроки снизить уровень энергопотребления зданий не менее, чем на 30-40%. Исходя из этого следует, что сегодня в мире и стране' проблема повышения теплозащитных свойств ограждающих конструкций зданий - одна из актуальнейших задач в строительстве. Одним из решений задачи повышения теплозащиты зданий является использование добавок диатомита и бентонита в составе энергосберегающих керамических кирпичей. Основным из них является разработка и освоение новых энерго – и ресурсосберегающего керамического кирпича, способного обеспечить требуемый уровень теплозащиты при сохранении прежних проектных решений зданий. Сложившиеся экономические условия в стране предопределяют новый подход к выбору эффективных строительных материалов для жилищного строительства. Поэтому в последнее время сложилась острая потребность в новых стеновых материалах, обладающих энерго – и ресурсосберегающими свойствами.

Ключевые слова: диатомит, бентонит, керамический кирпич, суглинок, шихта.