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Some structural aspects of heat resistant plates from brick fight

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ABSTRACT: The article describes some aspects of the analysis of structures of heat-resistant reinforced concrete slabs designed to cover the surface of brick ovens. Fragments of crushed stone from bricks were obtained as the main filler in the manufacture of heat-resistant facing slabs. The plate is reinforced for strength, and its protective zone is offset to the neutral axis to protect the armature from temperature. Contains analytical data on scientific research over the years, problems, conclusions about the need for research, the results of experimental tests, the results of studies of porosity and structural aspects of the developed design of heat-resistant plates. This heat-resistant reinforced concrete slab has passed natural tests in brick kilns of brick factories in Namangan and Andijan regions of the Republic of Uzbekistan. Conclusions are made about the application of the obtained research results in production.

KEYWORDS: brick, brick kilns, temperature preservation, heat-resistant plate, strength, porosity, structure, analysis, coarse aggregate, fly ash, sand, building materials, building structures, experimental research

I. INTRODUCTION

The country is taking large-scale measures to introduce energy and resource-saving technologies in the construction industry. The strategy of actions for the further development of the republic for 2017-2021, in particular, sets the tasks "... the widespread introduction of energy-saving technologies in production ..." [1]. One of the most important objects in the implementation of these tasks is the development of building structures that ensure the quality and efficiency of brick factories [2].

We know that the internal temperature in brick kilns can be around 1000 °C. Until recently, expensive heat preservative kaolin slabs were used to cover the surface of brick kilns. However, the high cost of such heat-resistant plates also affected the cost of the manufactured products, and a number of disadvantages were identified during the application process. In addition, covered structures made of this heat-resistant material allow it to be used for a maximum of 6-8 months. Therefore, the task was to conduct scientific research in this area, as well as to develop and experimentally study an inexpensive construction of a heat-resistant coating based on local industrial waste for brick ovens. Due to the lack of such heat-resistant cladding structures in many brick factories, one can see that the quality of the bricks produced has not yet been sufficiently ensured.

Scientists all over the world have carried out numerous studies of the thermal resistance of reinforced concrete structures and their materials and obtained the results [3-9, 12-20]. However, these studies deeply study the flammability of existing buildings and structures, as well as reinforced concrete structures, the conditions of the stress-strain state in structures in the event of a fire. The effect of high temperatures (600–1000 °C) for a long period (10–12 h) has been poorly studied, and insufficient research has been carried out to create heat-resistant structures. In particular, research on the technology of production of heat-resistant expanded clay concrete structures based on industrial waste is insufficiently developed.

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II. METHODS

In order to study the thermal quality of the developed heat-resistant reinforced concrete slab, the porosity of the building material of the reinforced concrete slab was studied. Infrared Fourier spectrometry (SHIMADZU, Japan, 2017) [6,12,13] was used. The internal structure of the prepared samples has been studied and analyzed. The number of oscillograms on the scale of the spectral range was 4000 ÷ 40 mm-1, the allowable was 4 mm-1, the signal-to-noise ratio was 60:1, and the imaging rate was 20 spectra per second.

The symbolic porosimetry method was used to study the porosity of refractory concrete using the Thermo Scientific Pascal 240 EVO symbolic porosimeter and the three composition types in the study. All samples were placed on a CD3 dilatometer, the air in the pores was removed using a vacuum device and filled with mercury. Then the dilatometer was placed in an autoclave of a Pascal 240 EVO mercury porosimeter, and the mercury penetration was 200 MPa. Using special available software, the total porosity (%), specific and relative volumes of porosity (mm3/g) were determined.

III. RESULTS AND DISCUSSION

The new heat-resistant reinforced concrete slab is made on the basis of industrial waste and is intended for use in building kilns for firing bricks and roofs, and is appropriate. In the manufacture of the proposed heat-resistant reinforced concrete slab, brick fragments are used in construction as a large aggregate. In recent years, scientific research carried out at brick factories in Namangan and Andijan regions has shown that new heat-resistant reinforced concrete slabs are resistant to high temperatures in brick kilns. The heat-resistant slab has been successfully tested for 5 years at brick factories in Namangan and Andijan regions. The offered reinforced concrete slab differs from the existing bearing gutters and roofing slabs in that they are as follows: a large unit of brick fragments is obtained in the form of a large unit; the working anchor moves a certain distance according to the calculation from the stretch zone due to the high temperature in the stretch zone (about 1000 ^{0}C); there are additional fillers that ensure the strength of the heat-resistant reinforced concrete slab.

Brick fragments added to the reinforced concrete slab define the macrostructure of the concrete slab. The strength and nature of cracks, their large or small size, shape and particle size distribution are also important. At the same time, sand determines the mesostructure of the reinforced concrete slab material and the water-cement ratio due to its adhesion to cement, and the slab design also plays an important role in the formation of the macrostructure in concrete.

The stability of the samples was determined in accordance with the requirements of international standards [10,11], approved in cooperation with the Commonwealth of Independent States. That is, according to the formula, $R = \alpha \frac{F}{A} K_W$ the average strength (R) of the concrete cube was 11.09-15.44 (MPa).

Porosity plays an important role in heat retention in the construction of reinforced concrete slabs, since the degree of heat retention is provided by porosity. Therefore, one of the most important characteristics of reinforced concrete slabs is porosity. Porosity is characterized by the spatial parameters of porosity, the fact that they are part of the total volume, their occupancy and placement due to differences in size, and the range of sizes. Also, IUPAK (International Union of Theoretical and Applied Chemistry) and according to the classification of M.M. Dubinin, the size of micropores (less than 2 nm) in cement stone made of reinforced concrete, mesopores (2-50 nm) and macropores (more than 50 nm)), as known to have famous subdivisions.

On this basis, 3 types of samples (I, II, III) were prepared for the experimental study of porosity-conductivity-heat resistance, and the porosity in their structures was investigated in several compositions. The indicators of the structural porosity of the prepared samples are presented in table 1:

CHARACTERISTICS OF STRUCTURAL POROSITY OF SAMPLES, TABLE 1

№	Indicators	unit of measurement	Amount		
1	2	3	I	II	III
1	Total porosity	мм^3/ g	88,38	158,15	154,75
2	The total pore area	мм^2/g	1,376	11,906	3,077
3	Average pore diameter	μm	0,2569	0,0531	0,2012

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4	Diameter between pores	µm	1,5094	0,1107	0,5941
5	Modal pore diameter	µm	0,0098	0,0089	0,0091
6	Total porosity of the sample	%	19,391	30,212	29,444

I, II, III - the total porosity of the samples was determined and a comparison histogram was built (Figure 1):

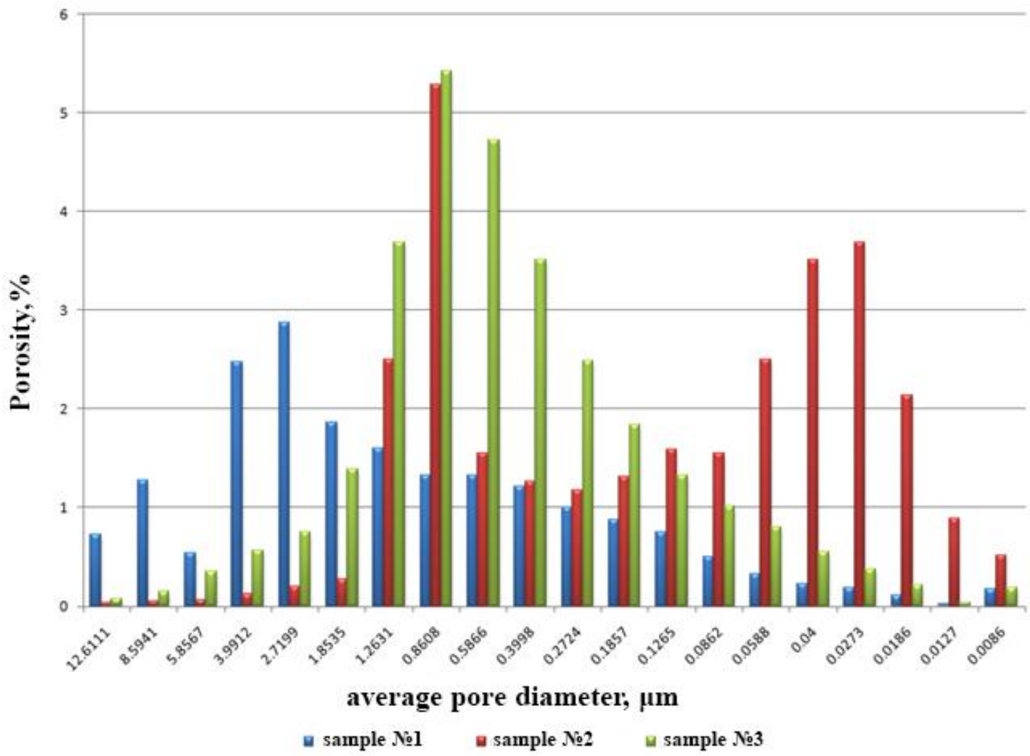

Figure 1. A histogram comparing the total porosity by size: the total porosity of the first sample is 19,391%, the second sample is 30,212%, the third sample is 29,444%.

Analysis of the above data shows that the total porosity of the first component is 19,391%. The contribution of the highest porosity based on the classification of M.M. Dubinin and [7-9] it was shown that it is in the range of 15–1,26 microns and that this porosity affects the physical and mechanical properties (strength, cold resistance and permeability) of concrete.

In the second composition, the main set of pores was in the range from 1,26–0.18 µm to 0,0588–0,0186 µm. The total porosity of the content was 30,212%.

The total porosity of the third investigated component was 29,444%. It was found that the main porosity is in the range of sizes 1,26-0,0862 microns. Based on the research results, a comparative table of the relative pore sizes of the samples was developed (Figure 2):

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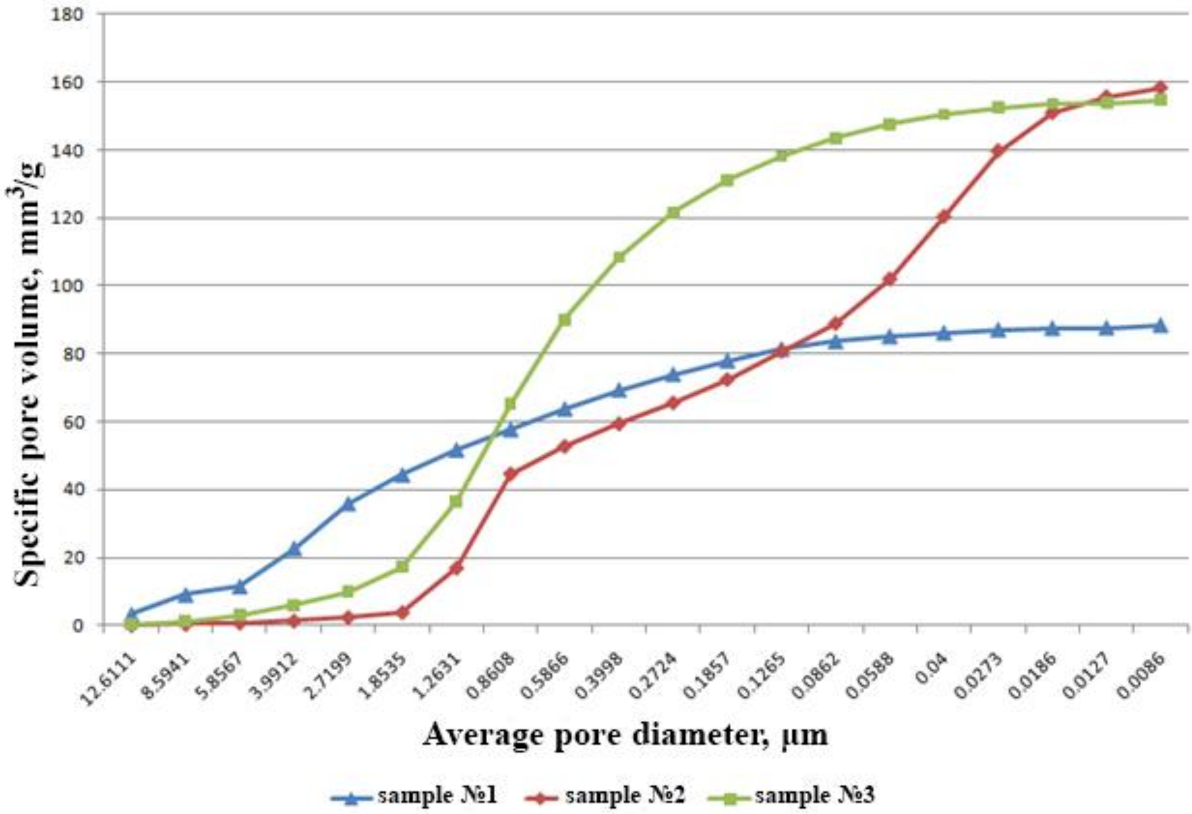

Figure 2. Graph comparing the relative pore volume of the samples.

When the specific volumes of the 2nd and 3rd samples were 158,15 and 154,75, it was noticed that the specific volume of porosity of the 1st sample was half as much (Fig. 3).

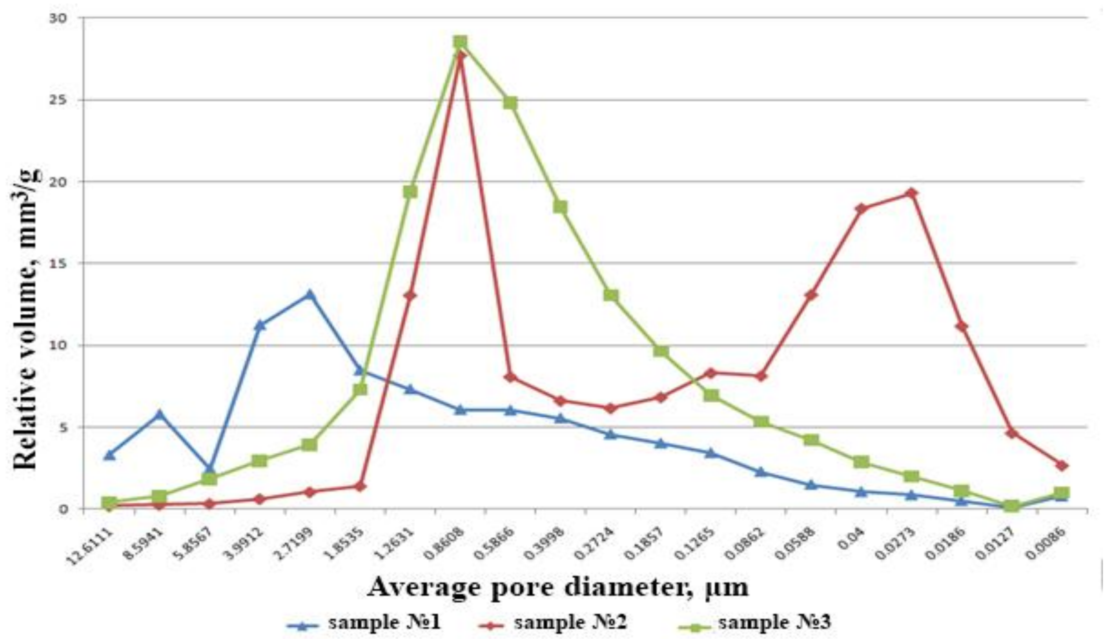

Figure 3. Graph of comparison of specific volumes of porosity of samples.

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Comparison of the volumes of relative and relative porosity of the samples showed that, on the basis of the theory of heat retention of pores, the expediency of using the second and third components as heat-resistant reinforced concrete structures was determined.

According to the research results, it was found that the total porosity of a heat-resistant structure is in the range of 20-30%. Therefore, it was noted that the manufacture of heat-resistant structures of these parameters can meet the regulatory requirements for them [12, 13].

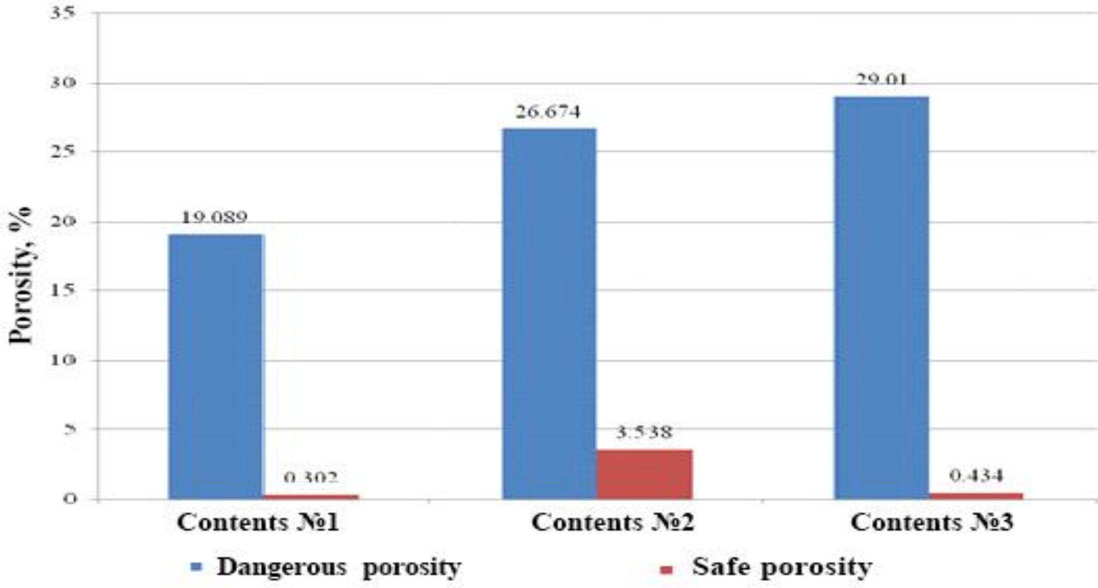

Figure 4. Dangerous and safe porosity of the investigated ingredients

In the study of M.M. Dubinin and [7-9] based on classifications, the hazardous and safe porosity of the studied compounds was studied (Fig. 4). It was found that the best content in terms of safe porosity is the second content. The highest risk porosity index corresponds to the third content.

Subsequent studies focused on microscopic analysis to study the composition of refractory concrete and the new composition in its structure. This, in turn, helped to get information about the new lineup. The research was carried out on the existing SHIMADZU device in the laboratory of the High Technologies Center in Tashkent. As samples, we used 3 (I, II, III) compositions: I) a brick sample of the Shokhidon brick factory (Namangan region); II) Sample of bricks from the Khanabad brick factory (Andijan region); III) a sample prepared in laboratory conditions (NamECI).

The results obtained for the chemical composition of the samples are shown in Table 2:

CHEMICAL COMPOSITION OF SAMPLES, TABLE - 2

№	**Element**			**weight,%**			**σ**		
	I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
1	O	O	O	41,1	41	47,9	0,9	0,8	1,0
2	Ca	Ca	Ca	30,6	35,7	19,9	0,6	0,6	0,5
3	Si	Si	Si	9,2	6,8	15,6	0,3	0,2	0,4
4	C	Al	C	6,4	5,4	9,4	0,7	0,2	1,6
5	Fe	C	Al	6,2	5,4	2,8	0,5	0,6	0,2
6	Al	S	Fe	4,8	2,6	1,6	0,2	0,2	0,3
7	S	Fe	S	0,9	2,1	1,4	0,1	0,4	0,1
8	Mg	Mg	K	0,9	1,0	0,5	0,1	0,1	0,1
9			Mg			0,8			0,1

I-sample. The results obtained at a depth of 250 μm using a brick sample from the Shokhidon brick factory (Figure 5):

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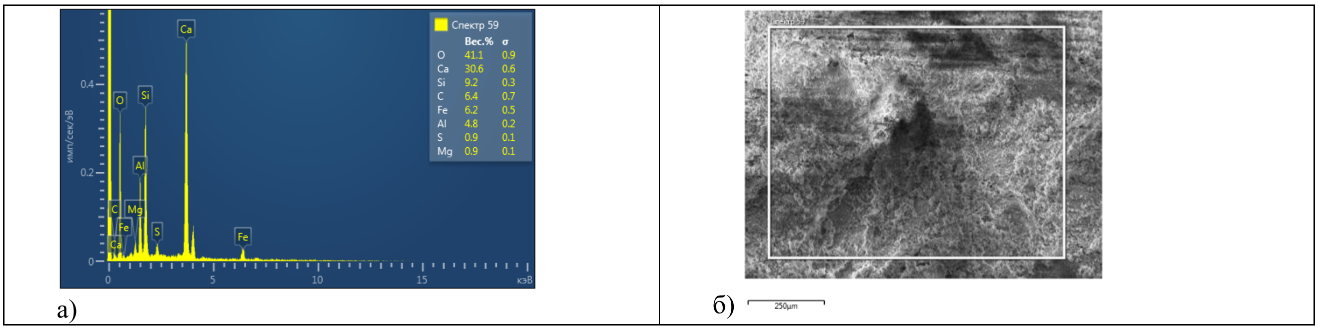

Figure 5. Results of X-ray phase and microstructural analysis (brick of the Shokhidon brick factory): a) results of X-ray phase analysis; b) Microstructure of a sample of heat-resistant ceramic concrete slab: cement, quartz sand, ash powder, crushed stone.

II- Sample. The results obtained at 250 µm on a sample from a brick of the Khanabad brick factory (Figure 6).

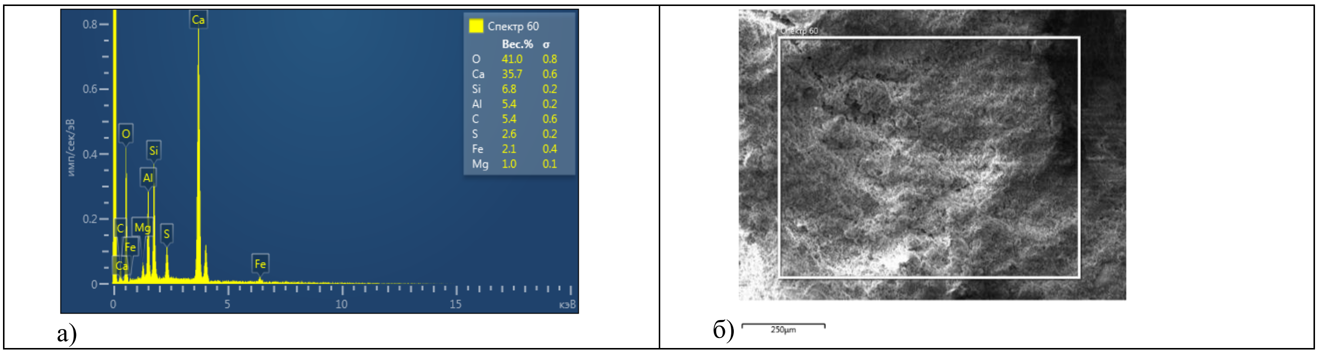

Figure 6. Results of X-ray phase and microstructural analysis (brick of Khanabad brick factory): a) results of X-ray phase analysis; b) Microstructure of a sample of heat-resistant ceramic concrete slab: cement, quartz sand, ash powder, crushed stone.

Sample III: Results obtained at a depth of 250 µm on a sample (NamECI) prepared in the Building Materials laboratory of the Namangan Engineering-Construction Institute (Figure 7):

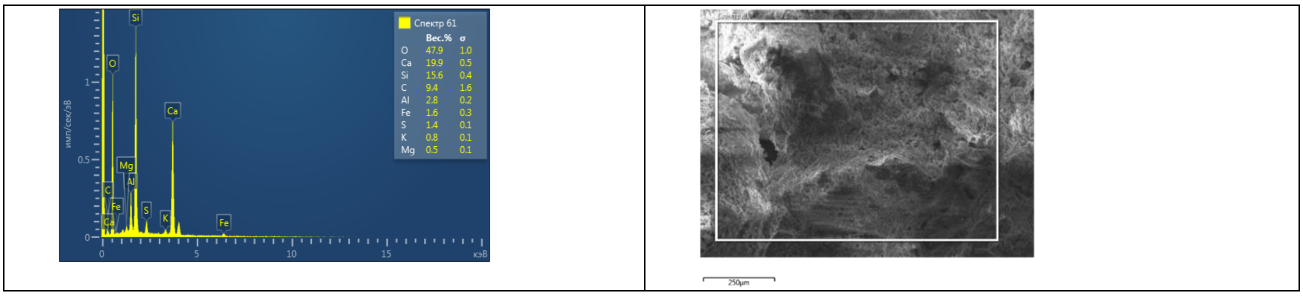

Figure 7. Results of X-ray phase and microstructural analysis (NamECI laboratory): a) results of X-ray phase analysis; b) microstructure of a sample of heat-resistant ceramic concrete slab: cement, quartz sand, ash powder, crushed stone.

In general, it is recommended that the selected composition of the proposed heat-resistant reinforced concrete slab for brick ovens should also be used to cover the walls of heating units.

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IV. CONCLUSION

As a result of tests on samples, the following conclusions were made:

1. According to the research results, it was determined that the total porosity of a heat-resistant structure can be obtained within 20-30%.

2. Based on a comparison of the volumes of relative and relative porosity and on the basis of the theory of heat retention of pores, it was determined that the second and third components can be obtained as heat-resistant reinforced concrete structures.

3. The highest degree of hazardous porosity was observed and determined in the third composition.

4. With regard to the proportion of safe pores, the second content turned out to be the best content.

5. As a general final recommendation, the most suitable formulation for use in heat-resistant structures is the second formulation.

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