

# Improving the optimal composition of heat-insulating structural aerated concrete based on industrial waste

Said Shaumarov\*, Sanjar Kandakhorov, and Umarali Abduraimov

Tashkent State Transport University, Tashkent, Uzbekistan

**Abstract.** This article presents the results of experimental research, which characterizes the parameters and properties of the porous structure of aerated concrete based on industrial waste. Structurally optimal parameters representing the physical-mechanical, thermal-technical properties of aerated concrete-based exterior wall structures have been identified. The test results were carried out in research laboratories using aerated block constructions with an optimal composition of high porosity and improved technological solutions of autoclaved aerated concrete.

## 1 Introduction

In today's world of advanced technology, the issue of recycling large amounts of waste that is spreading around the planet has become a pressing issue. Much work is being done around the world in this regard. For example, the concept of waste recycling and reducing their impact on the environment of the World Environmental Organization has a special place.

In the construction industry, as in all industries, the use of energy-saving materials, lowering the cost, the use of industrial waste products in construction is an effective raw material.

According to the results of laboratory tests, quartz sand used as industrial waste consists of the following indicators[1-2].

The use of heat-insulating effective building materials with an average density of 500-700 kg / m<sup>3</sup> and structural cellular concrete with an average density of 800-1200 kg / m<sup>3</sup> as energy-saving building materials increases its economic efficiency regard is important.

In developed countries, Germany, Sweden, the Russian Federation, the United States, Japan, Finland, and other countries are focusing on producing aerated concrete using industrial waste, increasing its heat, strength, moisture permeability [3]. This, in turn, has a positive effect on reducing the impact of industrial waste on the environment and increasing the economic efficiency of aerated concrete.

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\*Corresponding author: [shoumarovss@gmail.com](mailto:shoumarovss@gmail.com)

If we look at the world experience, using aerated concrete to increase the energy efficiency of the external barrier structures of energy-efficient buildings is important. At the same time, several manufacturing companies in developed countries, such as Wehrhahn, GRIVAS Ukraine, Masa, AltayStroyMash, East Mining Invest, Aerocon, increase the cost-effectiveness of aerated concrete in research laboratories, using industrial waste, research is underway [9-20].

B.P. Danilov and A.A. Bagdanov [4] fully demonstrated the technological capabilities of aerated concrete barrier structures of different densities. At the same time, the thermal conductivity of the aerated concrete structure was 7-10%, which allowed to eliminate the moisture formed on the inner surface of the structure, allowed to protect the working moisture from evaporation from the room by evaporation.

X. Xullmann, M. Schlaich, A. Lagoaz, P. Szymanski, P. Valczak, N.I. Levin, H. Weber's research results aim to improve the technology of aerated concrete and increase its efficiency [5-8].

In these studies, with the help of mineral and organic additives, plasticizers, research was conducted on various properties of aerated concrete, strength, thermal protection, optimization of porosity, reduction of moisture.

## 2 Materials and Methods

According to generally accepted standards, experimental studies were carried out using non-standard methods developed by scientific research experts, using laboratory wastes based on specified industrial wastes.

The study of the porous structure of aerated concrete blocks was performed using Thermo Scientific Pascal mercury porosimeter (Figure 1).



**Fig.1.** Thermo Scientific Pascal symbolic porosimeter

Experimental research and data processing were performed in the following sequence:

1. A vacuum for aerated concrete was created in the symbolic porosimeter "Thermo Scientific Pascal." The sample is filled into a vacuum flask, and mercury is added to it.
2. Mercury slowly enters the sample and fills its pores. The porosimeter then determines its porosity percentage based on the total size of the sample.

3. Upon completing the experimental studies, the data are processed in the prescribed order using a special computer program, and the necessary diagrams are created.

Upon completion of the laboratory analysis, the computer will automatically describe the dimensions of the porosity of the samples, the penetration of mercury into them, and the pressure tolerance diagrams.

The strength of aerated concrete samples for strength following the normative requirements of GOST 10180-2012 was determined using a hydraulic press (Figure 2).



**Fig. 2.** Hydraulic press

Determining the optimal porosity content of the specified structural heat-insulating aerated concrete was performed using automated computer software [9-12].

Determination of the strength of aerated concrete samples using a hydraulic press was carried out in the following sequence:

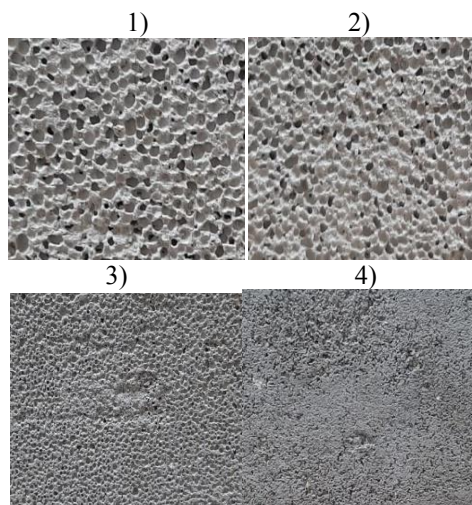
1. Aerated concrete samples in the form of cubes of size 100x100x100 mm were mounted on the press, respectively.
2. The samples were gradually loaded with increasing force and lost their previous state.
3. The maximum breaking strength values were recorded for each sample.
4. The average refractive power of several samples was determined, and its grade was determined.

External wall constructions of energy-efficient civil buildings for different climatic conditions of the Republic of Uzbekistan with the required thermal conductivity values were implemented using computer programs "Base."

### **3 Results and Discussion**

Study of physical, mechanical, and thermal properties of cellular concrete exterior wall structures determines criteria parameters of porosity of materials.

Aerated concrete blocks of D600 and D900 grades were selected for laboratory research. The prepared aerated concrete blocks consist of samples with dimensions of 100x100x100 mm (Fig. 3).



**Fig.3.** Exterior view of aerated concrete samples D600 (1, 2) and D900 (3, 4)

Non-autoclaved aerated concrete samples were identified using a computer program "Determination of aerated concrete properties based on image analysis" using the standard method [9-11].

The calculation of the properties of aerated concrete samples using a porosimeter according to the results of experimental tests is given in Table 1.

**Table 1.** The results of determining the characteristics of samples in laboratories

№	Average density, kg/m <sup>3</sup>	Density, MPa	Porosity,%
1	645	1.64	63.2
2	660	1.68	62.8
3	652	1.65	62.9
4	658	1.67	63.1
5	858	5.84	58.3
6	917	5.91	57.1
7	862	5.87	58.1
8	923	5.94	57.3

The results of tests of the same samples by GOST 10180-2012 are given in Table 2.

**Table 2.** Results of determining the characteristics of samples in production organizations

№	Average density. $\text{kg/m}^3$	Density. MPa	Porosity. %
1	646	1.52	61.8
2	667	1.58	60.2
3	656	1.53	61.4
4	662	1.56	60.5
5	861	4.86	56.2
6	889	4.92	54.4
7	868	4.88	55.2
8	892	4.96	53.8

A comparison of the average density, strength, and porosity of non-autoclaved aerated concrete samples determined by the proposed standard methods showed that the average density difference was (1–4)%; strength - (6.5 - 10.4)%; in terms of porosity - (1.3 - 4%).

However, the results obtained from the experiments on strength showed that the actual strength of D600 non-autoclaved aerated concrete is (10-12) % lower than indicated in the passport, D900 grades (6-8)% lower.

Studies have shown that it is possible to improve the thermal-technical and structural properties of aerated concrete, taking into account several factors, and to obtain a lot of real practical results from the analysis of the literature, optimize the porosity of aerated concrete and its application in thermal insulation buildings for all levels of Uzbekistan, technological methods have been developed that can be successfully applied in the field.

The technology developed for the production of autoclaved aerated concrete was tested in the production organizations. For this purpose, the compositions D600 and D900 were mixed following the developed technology. The samples were determined according to the porosity properties according to the standard method developed (Figure 4) [21-28].



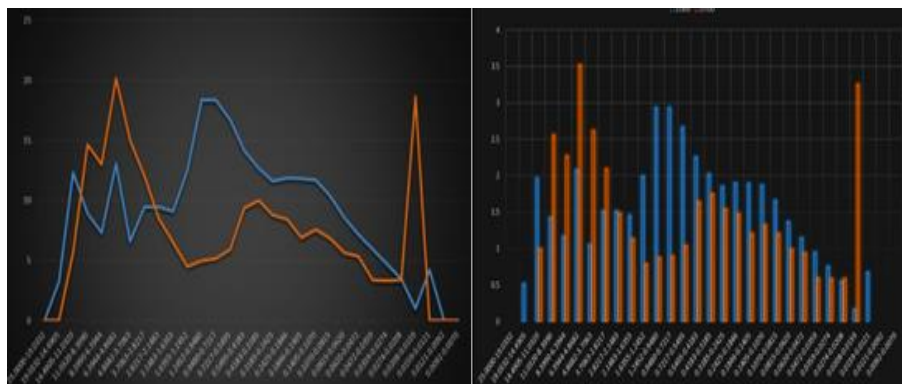
**Fig.4.** Photographs of surfaces of non-autoclaved aerated concrete samples D600 (a) and D900 (b)

Samples from each batch were investigated using the developed standard method; the results obtained are presented in table 3.

**Table 3.** Results of determining the characteristics of aerated concrete samples by the standard method

№	Average density. kg/m <sup>3</sup>	Density. MPa	Porosity, %
1	615	1.62	63.2
2	632	1.68	62.5
3	609	1.60	64.3
4	624	1.63	62.9
5	898	5.84	58.7
6	920	5.96	57.9
7	906	5.91	58.3
8	917	5.93	58.1

The porosity structure of the samples was checked using a porosimeter. According to the results of the study, the samples with the best characteristics were identified. The results of this experimental study are shown in Figure 5.



**Fig. 5.** Density porosity diagram of aerated concrete cells D 600. D900

As can be seen from the graph, we can determine the parameters and porosity percentages of energy loss from the parts of gas blocks and their resistance to strong pressure. In this case, the results of strength, porosity, moisture permeability, and fire resistance of gas blocks were compared. According to the comparison results, the advantage was 10.5% in the samples of D600 grade and 8.6% in the aerated concrete blocks of D900 grade.

Analyzing the obtained results, the ease of determining aerated concrete properties using the established standard methods, its average density of 1-3%; strength of 7.5 - 11.4%; porosity of 2 - 3.8% difference.

**Table 4.** Technical characteristics of autoclaved gas units obtained based on different technologies in different conditions

Composition, production conditions, technology	Aerated concrete grade			
	D600		D900	
	Characteristics of aerated concrete			
	Density, MPa	Porosity, %	Density, MPa	Porosity, %
Features of gas blocks in the production organization	1.51	61.1	4.9	56.0
Features of the proposed gas block	1.68	63.5	5.86	59.1

Analysis of the results of scientific research in autoclaved aerated concrete structures in research laboratories and production organizations showed that the material's porosity has a significant impact on its thermal and technical properties, strength.

## 4 Conclusions

1. According to the results of laboratory research conducted in industrial organizations and the developed method, the risk of dangerous cracks of porous autoclaved non-autoclaved gas blocks improved by 1-3%, porosity by 2.1-4.3%.
2. It is possible to increase the strength of the proposed gas blocks by 20-21%, sound insulation by 2-5%.
3. The results of the conducted experimental research laboratories showed that when the gas block was formed using waste sand, its cost was reduced by 2-3%.
4. In the process of production of aerated concrete blocks, the inclusion of the above and other types of industrial waste in the concrete composition, first of all, allows to save waste processing (disposal), binder (cement), increase the operational properties of the structure.

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