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General information about the operational properties of foam concrete as a modern energy-efficient building material

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Abstract: The thesis describes the characteristics of foam concrete as a perspective building material, attention to detail, its properties, economy and ecology. Indicated different brands of foam concrete, ix physical and mechanical properties. The importance of control over production processes to ensure the durability and stability of the material is emphasized. Despite numerous advantages, limitations of foam concrete have also been noted, such as low mechanical strength and shrinkage, which requires further research and improvements to improve its performance characteristics.

Keywords: foam concrete, non-autoclaved foam concretes, building material, mechanical strength, shrinkage

Cellular concrete occupies one of the leading positions among modern building materials due to the combination of high strength and thermal insulation characteristics. Its efficiency is due to the porous structure, which is a system of small, interconnected air cells, evenly distributed in the matrix of the material. This structure allows achieving the key characteristics necessary for energy-efficient materials: low density and low thermal conductivity. This makes cellular concrete a promising material for use in energy-saving construction. Cellular concrete is a large group of materials united by the presence of a porous structure. The main types of cellular concrete include: aerated concrete, foam concrete, foam aerated concrete.

Among them, foam concrete demonstrates high efficiency at densities of 300–1200 kg/m³, which allows it to be used both in thermal insulation and in load-bearing structures.

The first patent for the production of foam concrete dates back to 1925 and belongs to Bayer. Currently, foam concrete is experiencing a third revival. A new stage of research on foam concrete belongs to schools under the direction of professors G. P. Sakharov (Moscow), U. M. Makhambetova (Kazakhstan), L. B. Svatovskaya (St. Petersburg), M. S. Garkavi (Magnitogorsk), A. S. Kolomatsky (Belgorod) and others. Non-autoclaved concrete is actively being introduced as a structural heat-insulating and heat-insulating material, which has a number of advantages [1].

The following properties make foam concrete a promising material for use in energy-efficient and environmentally sustainable construction:

- Cost-effectiveness — production requires minimal equipment, reducing manufacturing costs.
- Thermal insulation — the thermal conductivity coefficient varies from 0.08 to 0.22 W/(m K), which meets modern energy efficiency standards.
- Fire resistance — foam concrete can withstand temperatures up to 1000 °C without losing its structural integrity.
- Environmental friendliness — consists of natural components that are safe for the environment.

The ability to regulate specific gravity, strength characteristics, thermal resistance, as well as shapes and volumes of products makes foam concrete a promising material for the production of a wide range of construction products.

In terms of durability, foam concrete has a significant advantage over materials such as mineral wool and foam plastics, which lose their performance characteristics over time. On the contrary, studies show that over time, foam concrete demonstrates improved thermal insulation and strength properties due to structural stabilization and material compaction processes.

In some countries, foam concrete blocks are called bioblocks; since only environmentally friendly natural components are used as raw materials. Foam concrete combines the qualities of stone and wood: strength, lightness, workability and does not require combinations with other building materials [1]

Table 1 presents the physical and mechanical properties of non-autoclaved foam concrete.

Table 1. The physical and mechanical properties of non-autoclaved foam concrete [2]

Property name	Average density, kg/m^3					
	400	500	600	700	800	900
Compressive strength class (B)	0,5 0,75 1,0	0,75 1,0 1,5	2,5 2,0 1,5	2, 5 2,0 1,5	3,5 2,5 2,0	7,5 5,0 2,5
Average compressive strength, MPa	0,7-1,5	1,0-2,4	1,4-3,6	2,2-3,6	3-7	3,5-10
Thermal conductivity in dry condition, W/(m·°C)	0,07-0,12	0,12-0,14	0,14-0,16	0,17-0,18	0,2-0,21	0,24
Sorption moisture, % by weight	5-8,4	4,7-8,3	4,4-8,2	4,1	3,8	3,5
Frost resistance, cycles	-	20	20	25	30	35
Shrinkage upon drying, mm/m	>3	1,8-3,0	1,7-3,0	1,7-3,0	1,7-3,0	1,7-3,0
Equilibrium moisture content, %	12	11	10	9	8	8

Many types of foam concrete are classified by the following main features:

1. By functional purpose. Foam concretes are divided into three groups: heat-insulating, heat-insulating-structural and structural. 2. By type of binder. In foam concrete production technology, cements and lime are mainly used as binders, less often gypsum. 3. By type of siliceous component. Quartz sand is most widely used, as well as fly ash from the combustion of brown and hard coal, metallurgical slag and waste from alumina production. 4. By hardening method. Foam concretes are divided into non-autoclaved, which require steaming, electric heating or other types of heating at normal pressure, and autoclaved, which harden at elevated pressure and temperature [3].

Non-autoclaved foam concrete is characterized by simplicity of technological production, a wide range of applications, and relatively low cost, which predetermined its popularity in the construction market.

Despite its many advantages, foam concrete has a number of limitations that must be taken into account when using it in construction. For example, the low mechanical strength of foam concrete compared to traditional building materials such as concrete and brick limits its use as load-bearing

structures for objects with high loads. This requires the use of additional reinforcing components or an increase in the density of the material, which increases the cost and weight of the product.
Shrinkage is another important issue when using foam concrete. Like many other building materials, foam concrete experiences plastic shrinkage during the hardening process, which can lead to deformations and cracks in structures. This phenomenon is associated with the loss of moisture during the hardening process, which leads to a change in the volume of the material. Particularly significant shrinkage occurs in the first days after production, which requires compliance with strict technological standards during the production and installation process. As a result, shrinkage control and stabilization of volumetric changes become important aspects for ensuring the durability and integrity of structures.
Thus, foam concrete is a multifunctional building material that combines the ability to regulate specific gravity, strength and thermal insulation characteristics. Its versatility allows the material to be used both as a structural and thermal insulation element. In addition, some disadvantages such as low mechanical strength, shrinkage, low water resistance require deep scientific research and promising solutions to improve the performance properties of foam concrete.

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