Modification of non-autoclaved foam concrete with dispersed-reinforced fillers

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Abstract The paper examines defects of non-autoclaved foam concretes that complicate the management of structure formation processes at the macrostructural level. The main methods for improving the performance characteristics of foam concrete using dispersed reinforcement as a formulation solution are considered. An analysis of the effect of the inclusion of reinforcing fibers, such as basalt fiber, on the mechanical properties of the material and frost resistance is carried out. The results obtained confirm the prospects for the introduction of the described technologies to expand the areas of application of foam concrete and improve its operational reliability.
Keywords: non-autoclaved foam concretes, reinforcing fibers, basalt fiber, mechanical properties of the material, frost resistance.

Despite the apparent simplicity of the technological process for obtaining non-autoclaved foam concrete, the formation of the macrostructure of composites is difficult to control and regulate, which is due to a complex of factors that affect the structure formation of the material. In this regard, there is a high probability of the formation of structural defects (deformation and unification of pores, crack formation) and fluctuations in properties that reduce operational characteristics [1].

One of the traditional disadvantages of non-autoclaved foam concrete is its low resistance to tensile loads, as well as increased fragility, which during production, transportation and installation leads to the occurrence of defects such as chips and cracks. These damages significantly reduce the operational characteristics of the material. According to the analysis of the literature [2,3,4], research in the field of dispersion-reinforced cellular concrete deserves special attention, since they can offer effective methods for improving the strength and operational properties of foam concrete.

The solution to the above problems becomes possible if both the formulation and technological aspects are taken into account.

The formulation methods are related to the selection of raw materials, which is key to the formation of high-quality foam concrete.

In modern research devoted to strengthening materials based on mineral binders, two main directions can be distinguished. The first direction involves the use of special primers that facilitate the organization of the hardening processes of cement stone and the improvement of its physical and mechanical characteristics.

According to research by V.V. Timashev, the use of filiform crystals of calcium hydrosilicates in concrete leads to a significant increase in bending strength by 2–4 times. Directional crystallization of new formations promotes dispersed self-reinforcement of cement stone due to the formation of oriented crystal hydrates in its volume, which significantly improves the quality of concrete. The second direction is to use reinforcing fibers that differ in their composition from the matrix material and are capable of withstanding higher tensile stresses in comparison with the matrix during the operation of the composite material[4].

Dispersed reinforcement (fiber), being an extended phase separation surface, is the most important structure-forming component in foam concrete mixtures. The physical and geometric characteristics of fiber, such as its material nature, cross-sectional area, length and its quantitative content, play a decisive role in the following aspects:

- ensuring the duration of preservation of the formed cellular structure during the mixing process;
- determining the degree of defectiveness of interpore partitions, which directly affects the mechanical properties of hardened concrete [5].

In the works of I.G. Kalugin [5] improvements in the operational properties of foam concrete with the help of dispersed reinforcement are noted. The strength of foam concrete dispersed-reinforced with basalt fiber: grade 400 increases by 69% under bending; by 55% under compression; grade 800: increases by 42% under bending; by 36% under compression. Frost resistance of foam concrete and foam concrete dispersed-reinforced with basalt fiber increases to 100 cycles. Shrinkage deformations of dispersed-reinforced foam concrete decrease by more than 2 times.

According to the research of Bogatin A.Yu. [6], it was established that dispersed reinforcement leads to a change in the stress-strain state of the material under the action of compressive loads, therefore the parameters of its prismatic strength are 30-35% higher than the cube strength. In addition, the research showed that with optimal reinforcement parameters, the modulus of elasticity of fiber-reinforced foam concretes under tension exceeds similar indicators of equal-density foam concretes by 15-20%. It was also established that dispersed fiber reinforcement contributes to an increase in tensile strength under splitting by 1.2-2.5 times.

Based on the analysis, the following conclusion can be made: the use of dispersed reinforcement and optimization of the component formulation significantly affect the improvement of the performance characteristics of non-autoclaved foam concrete. The inclusion of reinforcing fibers, such as basalt fiber, as well as the use of seedings to improve the structural characteristics of cement stone, contribute to an increase in the tensile, bending and compression strength of foam concrete, improved frost resistance and a decrease in shrinkage deformations. These methods can significantly improve the mechanical properties of the material, which makes it more resistant to defects, such as cracking, and expands the possibilities of wide application of foam concrete.

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