Foam concrete production with addition of microsilica

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Abstract. The article deals with the influence of microsilica on technological properties of cement matrix and finished foam concrete. The possibility of replacing a part of the binder with microsilica was evaluated.

One of the current trends in the development of the construction market is the wide use of cellular concrete - artificial stone with evenly distributed pores. The pore structure is created mainly with air-absorbing additive (aerated concrete), or with foam (foamed concrete).

Rational use of articles made of foamed concrete is due to relatively high strength and operational properties at low density, which allows to significantly reduce the weight of the structure while ensuring the required structural and heat insulation indicators, which, in turn, creates prerequisites for effective solution of resource and energy saving problems in construction [1,2].

The disadvantage of foamed concrete is low initial strength, in the result of which articles acquire undesirable chips and cracks during production and installation. Analysis of studies and theoretical data [3,4] allowed to determine two main ways of strengthening the material with preservation of technical properties and low density - strengthening of the framework (inter-pore partitions) [5,6] and improvement of the pore structure.

Directed structuring in cellular concretes is achieved due to reduction of the amount of water and introduction of various active additives (mineral, fibrous) [7]. It is obvious that it is most advantageous to use additives with a high specific surface area that do not require complete grinding, for example microsilica.

Microsilica (MS) is a waste from the production of silicon-containing alloys, an ultradisperse material consisting of particles of spherical shape with a size of 0,01 – 0,1 μm. The main component of the material is amorphous modification silicon dioxide containing up to 95% pure amorphous silica, which is able to react actively with lime released by portland cement during its hydration to form water-insoluble substances.

The use of MS can help to reduce the cost of construction materials, as well as improve the environmental situation in the Irkutsk region [8].

In order to determine the amount of microsilica to which cement can be replaced in the foam concrete composition without deterioration of the main physical and mechanical properties of the latter, a series of experiments was carried out to determine the mobility of the cement slurry, the strength of the cement matrix, as well as the density, strength and thermal conductivity of the foam concrete, cast using the MS of the Bratsk Aluminium Plant.

Composition of cement mortar included cement of grade M500D0, water and MS, replacing from 5 to 15% of cement weight. Ratio of water and solid components (cement and MS) - Water/Solid,
ranged from 0.4 to 0.6. According to [8], the density of the future material depends on the diameter of a spreading of the initial mixture according to the Suttard viscometer. Thus, in order to obtain a density of 600 kg/m$^3$, the diameter must be 24 cm. Solutions mobility measurement results are shown in Figure 1.

**Figure 1.** The dependence of diameter of a spreading of the initial mixture on the water-solid ratio: 1 - is a control sample; 2 - with replacement of 5% mass of cement MS; 3 - with replacement of 10% by weight of cement MS; 4 - with replacement of 15% mass of cement MS.
Figure 2. The dependence of the strength of the cement matrix on the water-solid ratio: 1 - is a control sample; 2 - with replacement of 5% mass of cement MS; 3 - with replacement of 10% by weight of cement MS; 4 - with replacement of 15% mass of cement MS.

It can be seen that at Water/Solid from 0.4 to 0.5, the addition of MS results in an increase in the water demand of the mixture due to the high specific surface area of the additive. The diameter of a spreading was less than 18 cm, suggesting that the required density of the material could not be obtained at such component ratios. With an increase in Water/Solid, there is an increase in plasticity and, accordingly, mobility of weight. The desired diameter of a spreading (24 cm) at Water/Solid ranging from 0.53 to 0.58, depending on the amount of MS used. But such a large amount of water in the mixture will not produce a material with acceptable density and strength. Therefore, to achieve the desired parameters of foam concrete, it is necessary to use plasticizing additives. Based on the results of the mobility measurement, the rational ratio of components of the foam concrete mixture was determined.

Further from samples of solution beams of 40×40×160 mm in size prepared, and after 28 days their strength at compression (figure 2) was defined.

It can be seen from the graphs that the replacement of more than 5% by weight of the cement with microsilica at leads to a significant reduction of the matrix strength (lines 3, 4). The strength of the control sample (without the addition of MS) and the sample containing MS in 5% of the weight of the cement had the highest value at Water/Solid of 0.5.

At the next stage foam concrete with design density of 600 kg/m³ was prepared according to classical technology - cement mortar containing MS in quantity from 5% to 30% of cement weight was mixed with foam.

The effect of the amount of MS added on the density of the material was found: that with the addition of microsilica over 15% by weight, there is a significant decrease in density. In addition, visual analysis of the corresponding samples revealed a disturbance in the uniformity of their structure, which will inevitably have a negative impact on the construction and technical properties of

Figure 3. The dependence of the compression strength of the foam concrete samples on the amount of microsilica.

The results of determining the compression strength of the foam concrete samples are shown in
Figure 3. It is evident that the addition of MS to the foam concrete composition without the use of plasticizing additives leads to a reduction of this critical parameter. According to [10], at density of 600 kg/m³ the strength of foam-concrete should not be less than 1.5 MPa. Experiments have found that this requirement can be met by replacing up to 5% by weight of the cement with microsilica.

Analysis of thermal properties of foam concrete shows (Figure 4) that thermal conductivity of samples prepared using MS is on average 2 times less than that of the control sample and varies in the range from 0.12 to 0.08 W/(m•K), corresponding to [11-15].

![Thermal Conductivity of Foam Concrete](image)

Figure 4. The dependence of the thermal conductivity of the foam concrete samples on the amount of microsilica.

A number of conclusions can be drawn from the studies:
- It is possible to replace up to 5% of cement with microsilica without deterioration of physical and mechanical properties of the obtained foam concrete;
- Introduction of MS into the composition of foamed concrete leads to reduction of its thermal conductivity, which can be used in manufacturing of heat-insulating materials;
- to improve the strength characteristics of foamed concrete made using microsilica, the amount of water in the mixture (water-solid ratio) should be reduced. It will be appreciated that plasticizers are required.

Accordingly, it is necessary to continue research in this direction using modern plasticizers, which may increase the strength of the product.

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