Influence of properties and amount of foam on quality of foam concrete

Sergey Shcherbin¹, Pavel Gorbach¹ and Andrey Savenkov¹

¹Federal state-funded educational institution of the higher education "Angarsk state technical university", 665835 Angarsk, Russia

Abstract. The article considers influence of nature and amount of foaming agent on stability, multiplicity, strength and coefficient of foam use and also heat conductivity and strength of non autoclaved foam concrete.

1 Introduction

Foam concrete is an environmentally friendly, durable and rather cheap artificial stone material received as a result of solidification of the system consisting of cement and sand mix and foam. Respectively, one of the pacing factors affecting properties of foam concrete is the quality and amount of the used foam.

Foam is a heterogeneous system which structure is defined by a ratio of volumes of gas and liquid phases. Depending on this ratio a cell of foam can have a spherical or many-sided shape. A cell has a spherical shape if gas the volume exceeds liquid volume no more than at 10-20 times. The foam state with many-sided cells is close to equilibrium therefore such foams are more stable than foams with spherical cells.

In this work known [1, 2] are foams to be characterized by stability, multiplicity and mechanical strength. Results of an integrated study of the main characteristics of foams and their impact on heat conductivity and
mechanical strength of cell concrete of non autoclaved curing are given.
For this purpose multiplicity, stability and mechanical strength of foams were defined, the coefficient of foam using was calculated. Further foam concrete samples were made strength and coefficient of heat conductivity were defined.

2 Materials and methods

At a research synthetic foaming agent Penta 430A, technical water, cement of brands M 500 D0 and M 400 D20 the production of the Angarsk cement works were used.

Stability of the foam prepared with use surfactant and service water was defined by lifetime of a half of its volume. Concentration of foaming agent changed in the range from 0,25 %\text{mass} to 1,5%\text{mass} with a step 0,25 %\text{mass}.

At the following stage the multiplicity of the foams prepared on service water at a temperature 20 °C as the foam volume relation to the volume of solution of the foaming agent containing in it was defined.

Further the mechanical strength of foam was estimated. The “breakdowns” method of foam was for this purpose used [3]. The course of the experiment was follows: in glass cylinders with a capacity of 200 ml from the solutions different content of foaming agent foam samples were prepared, then a load was placed on the surface of the foam and the time for which it would fail to the bottom of the cylinder was recorded. The mechanical strength of the foam can be indirectly estimated by the rate of immersion.

The results of definition of stability, multiplicity and mechanical strength of foam allowed to estimate the quality of foaming agent and to indentify the range of concentration at which the resulting foam has the best technological properties. However, this series of experiments does not fully take into account the production technology of foam concrete of which feature is hashing cement with foam that leads to mechanical destruction of the latter and, as a result, deterioration in properties of ready material. Therefore, when receiving commodity foam concrete it is necessary to consider properties of a heterogeneous system: foam, cement, technical water and filler. For this purpose the parameters of foam-cement mortar were estimated.

Preliminary experiments showed that the foam is influenced by additives used in the production of cement. So, using of cement of brand M 400 D20 foam destruction process was observed that did not allow receiving foam
concrete of the required low density and led to rejection of samples.

To assess the effect of the binder on amount of foam it is accepted to determine the coefficient of foam using (CFU), i.e. the ration of volume of foam and cement mass to the initial volume of foam. It is considered [4] that good foam has to possess CFU equal 0.8-0.85. Preliminary experiments showed that when the concentration surfactant to 0.5 %\text{mass} is not enough resulting foam for creation of foam and cement mass with constant properties, and at the concentration more than 2.5 %\text{mass} there is an excessive consumption of foaming agent and the homogeneity the foam structure is broken. Therefore the operating range of concentration from 0.5 %\text{mass} to 2.5 %\text{mass} was chosen.

Samples of foam were prepared on the basis of solutions with the different content of foaming agent and their volume was measured. Then the binder was mixed with the resulting foam, re-measured the volume of foam-cement mass and was determined the coefficient of foam using.

### 3 Results

The results of measurement of stability of the foam prepared with the use of surfactant and technical water are given in figure 1. With an increase in the concentration of the foaming agent in the solution, the stability of the foams increases, reaching the maximum value at critical concentration of a formation of micelles about 1 %\text{mass} [5], then the stability decreases. It can be explained by Marangoni-Gibbs's effect, lies in the fact that in surfactant concentration above a certain barrier there an outflow of liquid from Plateau "triangle" leading to destruction of bubbles foam [1].

The results of determining the multiplicity of the foams prepared in technical water at a temperature 20 °C are shown in figure 2. The resulting foams have an average multiplicity (multiplicity from 6 to 10) [1] and can be used for the production of foam concrete according to the classical technology. It is also seen that at concentrations of surfactant 1 %\text{mass} or more increase of multiplicity practically stops.

Results of determination of mechanical strength of foam by the breakdowns method of foam weight are given in figure 3. From the schedule it is well visible that in the concentration range surfactant from 1.2% to 1.3% the speed of movement of freight is minimum and strength of foam reaches the maximum value.

The results of determining of CFU are illustrated by figure 4. The analysis of the obtained data allows to allocate two sites with different
intensity of change of CFU: at concentration up to 1% significant increase in coefficient is observed; at achievement of concentration more than 1% the change of CFU slows down. The coefficient of foam using values, acceptable for production of foam concrete, are obtained at surfactant of concentration more than 1 %mass.

**Figure 1.** The dependence of stability of the foam on concentration of the foaming agent.

**Figure 2.** The dependence of the multiplicity of foam on concentration of the foaming agent.
Figure 3. The dependence of speed of the movement of freight on concentration of the foaming agent.

Figure 4. The dependence of the coefficient of foam using on concentration of the foaming agent.

The results of determination of coefficient of heat conductivity of foam concrete of brand D 400 showed (figure 5) that heat technical properties of foam concrete are improved with increase in concentration of the foaming agent. At concentrations of foaming agent of 1% and more material the requirements [6] according to which heat conductivity of this grade of foam concrete has to be not less than 0,09 W/(m·K).

The largest strength was received for samples in the production concentration surfactant was about 1 %\textsubscript{mass} (figure 6). Reduction of strength of material at high concentrations of foaming agent can be explained by the fact that are excess content of the latter leads to delay of terms of hydration of cement.
Figure 5. The dependence of coefficient of heat conductivity of foam concrete on concentration of the foaming agent.

Figure 6. The dependence of the strength of foam concrete on concentration of the foaming agent.

4 Discussion

A number of the fundamental [1, 2, 7, 8] and applied works [3-5, 9-13] devoted to studying properties of foaming agents and foams is published. By the results of studying and comparison of the properties of different synthetic and proteinaceous foaming agents the most perspective foaming agent for non-autoclaved technology – Penta 430A [5] was revealed. It is established that at low concentration surfactant the volume of the obtained foam is
insufficient to form of future foam concrete, and, as a result, the required properties of material. At high concentration there is significant deceleration of process of a solidification of a cement system that leads to reduction of strength of products [10], and also to increase their cost. In works [11, 12] three ranges of concentration of foaming agent are revealed: small – from 0,1 % to 1 %, averages – from 1 % to 3 %, big – from 3 % to 5 %. As it is also shown, that properties of foam very over a wide range and are directly connected with type and concentration surfactant. This must be be considered in the production of foam concrete.

Another serious problem faced by producers of cellular concrete of not autoclave hardening is the lack of a technique for determining the required amount of foaming agent at a design stage of composition of material. The existing normative documents [6, 14] have been partially cancelled or are significantly outdated and do not meet modern requirements.

The features of the interaction of foaming agents with other components used in the production of non autoclaved foam concrete are not fully studied. Most of the works do not take account the production technology of material the features of which is hashing knitting with foam that leads to mechanical destruction of the latter and, as a result, to deterioration in the properties of finished material. Therefore when receiving commodity foam concrete it is necessary to consider the properties of a heterogeneous system – foam, cement, technical water, filler.

5 Conclusions

It is experimentally established that in the production of not autoclave foam concrete of the brand on density of D 400 using of synthetic foaming agent Penta 430A for obtaining strength of material comparable to strength of autoclaved gas concrete without degradation in heat-insulating properties, concentration of surfactant has to vary in the range from 1 to 1,5 %mass.

The approach applied in this work can become a part of a new technique of design of the composition of foam concrete of non autoclaved curing allowing receiving material with the required strength and coefficient of heat conductivity.

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