Risks in Managing the Physical Parameters of Foams for Cellular Concrete

V G Borkovskaya1,2, V I Rimshin2,3, E N Degaev2, LI Shubin4
1Plekhanov Russian University of Economics, Stremyannyy Pereulok, 36, Moscow, 115093, Russia
2Moscow State University of Civil Engineering, Yaroslavskoe shosse 26, Moscow, 129337, Russia
3Research Institute of Construction Physics of the Russian Academy of Architecture and Construction Sciences, st. Lokomotivny passage, 21, Moscow, 127238, Russia
4Capital Group, Presnenskaya promenade, 8, Moscow, 123317, Russia

E-mail: BorkovskayaVG@mgsu.ru, info@professorstoday.org

Abstract. The main issue of the study is the problem of risks and changes in the physical parameters of cellular concrete foams. As part of the detailed analysis, it is necessary to comply with the requirements to ensure risk reduction, environmental safety, public health and consistency of any management of physical parameters of foam, as well as to improve the quality of life. The aim of the study is to reduce costs, reduce the marriage of finished products and achieve stable results, technology for the production of foam concrete should know the mechanism and process of obtaining foam. The system of indicators should be tiered, to take into account the multiplicity, stability, dispersion, density, structural mechanical properties, bearing capacity, impact on the change of melt finished mixture, hydrophobization, gidrofilizatsii, the influence of foaming agents on the hydration (setting) of cement. In conclusion, the proposed analysis can be used in the regulatory and technical regulation of technology for the production of foam concrete in construction and production.

1. Introduction

Foam concrete is a building mixture with a porous structure. Its main components are cement mortar and foamed foaming agent—a liquid whipped to a foam state. Thanks to it in foam concrete the bubbles isolated from each other which are enveloped by cement are formed and so form pores in the stiffened material. The number and density of pores depend on what foaming agent for foam concrete was used and what is its percentage in the solution. Foam blocks have a number of advantages, thanks to which they received their popularity.

Some of the advantages they owe it to the use of foaming agents:

• Good thermal insulation. The content of air bubbles in the material allows you to keep the heat in the room in the cold season and have a cool in the summer heat.
• Soundproofing. Again, thanks to air bubbles, sound does not pass through walls so easily.
• Light weight of the structure. This reduces the cost of laying the Foundation and facilitates the construction of the walls of the building.
In order to reduce costs, reduce the marriage of finished products and achieve stable results, the technologist for the production of foam concrete must know the mechanism and process of obtaining foam. At the same time, he must know all the characteristics that allow to assess the quality of foam and predict the quality of future products. [VB 1-3]

In the manufacture of foam based on the following indicators foaming agents:

- **Multiplicity** - the ratio of the volume of foam to the volume of foaming agent required for its production.
- **Stability** – the decay time (reduction) of a certain amount of foam for a certain period of time.
- **Dispersion** - the value that determines the average size of the bubbles, as well as their distribution over the foam volume.
- **Density** – the ratio of foam volume to mass.
- **Structural and mechanical properties** - the ability of bubbles (honeycomb) to retain its original shape.
- **Bearing capacity** - the ability of bubbles (honeycomb) foam to hold on its surface the cement-sand mass, while not collapsing for a long time.
- **Influence on the change in the melt of the finished mixture.**
- **Hydrophobization or hydrophilization of the internal structure of foam concrete.**
- **Influence of foaming agent on hydration (setting) of cement.**
- **Compatibility of foam with specialized additives (reinforcing fiber, plasticizers, accelerators, etc.).**

### 2. Materials and methods

Multiplicity of foaming agent and foam stability are the main physical properties of technical foam, characterizing the quality of foaming agent. They depend on the type of foaming agent, foam preparation device, which greatly affect the physical and mechanical properties of porous concrete. The multiplicity of the foaming agent should be at least 10. This is necessary to reduce the negative effect of foaming agents on the hydration of the binder.

The multiplicity of the foaming agent is determined by the formula:

\[
K = \frac{V_r}{V_f},
\]

where \(V_r\) is the volume of the foaming agent working solution, m³; \(V_f\) is the volume of the resulting foam, m³.

The strength of foam concrete is influenced by the amount of water introduced into the porous mixture with foam, which leads to additional formation of capillary pores. Reducing the water-solid ratio in the porized solution changes the value of the foam resistance coefficient, which leads to an increase in the density of the resulting foam concrete. Therefore, in the technology of foam concrete, some manufacturers use a relatively high value of the water-solid ratio. Due to this technological method, increasing the value of the coefficient of resistance, it is possible to obtain foam concrete of lower density, reducing the negative impact of the foaming agent on the hydration of the binder. The use of high multiplicity foams ("dry foams") leads to the redistribution of water from the hardening solution into the inter-film layers of foam bubbles. This effect is observed when using certain types of foaming agents and foams of high viscosity.

A necessary condition for obtaining high quality foam concrete is the use of effective foaming agents and technological methods that provide high foam stability in the foam concrete mixture [VB4-7]. One of the main characteristics of a stable film is its resistance to mechanical stress. Gibbs considers the elasticity of the film as such a characteristic [1]:

\[
E = 2 \cdot d \cdot \gamma / d \cdot \ln \cdot A,
\]

where, \(A\) is the film area, \(\gamma\) is the surface tension.

The durability of the porous mixture in time is characterized by the precipitation of the foam concrete mixture. The deposition process is influenced by changes in the pH of the hardening concrete medium and redistribution of surfactants (surfactant - foaming agent) in the dispersed system. With insufficient structural strength of interstitial partitions (the result of surfactant action), their
breakthrough and fusion occur. Such changes in the porous mixture over time are measured by the height of the precipitation of the porous mixture to its initial height. The less sediment the concrete mix, the better the foam and technical foam prepared.

3. Results and discussion
For the preparation of foam concrete of different brands, different types of foaming agents are used, which differ not only in the flow rate and chemical formula, but also in the basic physical parameters, which are characterized by the multiplicity and stability of foams.

Increasing the multiplicity of foams is due to the volume of air involved in the production of foam concrete, so this figure is recommended to control the operators in manual mode. Another determinant of foam – stability, which depends not only on the multiplicity of foam, but also on the viscosity. Due to the fact that the multiplicity of foam is not a constant characteristic and is highly dependent on external conditions, the impact on the quality of foam and foam concrete will be through increasing the viscosity without increasing the multiplicity of foam. An extreme increase in foam multiplicity leads to a weak cellular concrete structure, as the Plateau-Gibbs canals will lack sufficient water required for hydration in the cement slurry system.

It is proposed to increase the stability of the foam with the help of fatty alcohols. The influence of dodecyl alcohol on the stability of the foaming agent, which can now be found in the public domain, was considered. Directly present in the composition of the main component, as lauretate sulfate. The name of the foaming agent is conditional to exclude claims from the manufacturer. As a working concentration, the manufacturer recommends 1% in bulk. The results of the study of the effect of viscosity on the stability of foams are presented in Fig. 1.

![Figure 1](image)

**Figure 1.** Effect of dodecyl alcohol concentration on stability of laurette sulfate foam: F-1 (without dodecyl alcohol); F-2 (2% dodecyl alcohol); F-3 (4% dodecyl alcohol); F-4 (6% dodecyl alcohol).

As can be seen from the graphs, the stability of the foam increases from 170 to 275 seconds, while the multiplicity of the foam does not change and remains at 10. In addition to increasing the stability of dodecyl alcohol increases the surface activity of the working solution.

For rice. 2 the results of measurements of the surface tension of the studied solutions are shown. The graphs show a strong influence of fatty alcohols on the surface activity, which is confirmed by a decrease in surface tension from 24.4 to 18.6 mN / m.
In addition to increasing the stability of the foam with the help of fatty alcohols, we were able to reduce the surface tension of working solutions, which have a number of advantages over the initial solution. Mainly low surface tension has a higher wetting capacity and significant structural strength of the films formed. The results of studies of the viscosity of water films are shown in Fig. 3.

Studies of the viscosity of water films was carried out on the viscometer Brookfield (Fig. 4). The results indicate an increase in the viscosity of water films by more than 3 times on the entire spindle speed scale (№6): as previously noted, the increase in viscosity also leads to an increase in the structural stability of the foams in the cement slurry system due to the fact that the water required for hydration will remain in the foam channels, thereby preserving the dispersed system at the time of setting of the concrete.
Figure 4. Time of water film viscosity test on Brookfield viscometer.

4. Conclusions

In the initial period, surfactants, which are the main part of the foaming agent, strongly affect the hydration of cement. There is a kind of "poisoning" of cement. This is explained by the fact that in the process of crystallization of tumors from the cement gel, colloidal adsorption shells of the foaming agent are formed between them. They prevent the direct accretion of grains with each other and inhibit the formation of a strong spatial framework. To prevent "poisoning" and accelerate the processes of hydration of cement, special additives – accelerators should be used. The use of fatty alcohols is recommended as a stabilizer of structural strength and stiffness of the cement-foam system.

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