BUILDING MATERIALS AND PRODUCTS

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Voronezh State University of Architecture
and Civil Engineering
Ph. D. in Engineering, Senior Lecturer of Department
of Descriptive Geometry and Graphics N. L. Zolotareva
D. Sc. in Engineering, prof. of Department
of Building Products and Constructions Technology E. I. Shmitko
Voronezh State University
Ph. D. in Chemistry, Assoc. Prof. of Chemistry
of High-molecular Compounds and Colloids Department T. N. Poyarkova
Russia, Voronezh, tel.: +7(4732)71-53-21;
e-mail: fisis@vgasu.vrn.ru

N. L. Zolotaryova, Ye. I. Shmitko, T. N. Poyarkova

DEPENDENCE OF PROPERTIES OF FOAM OF GAS-FILLED BUILDING SYSTEMS UPON TECHNOLOGICAL FACTORS

The results of investigations of technological factors influence on properties of foam of gas-filled building systems are presented. This properties offer the prospect of purposive control of formation of porous concretes structure with different density.

Keywords: surfactant species, critical concentration of micelle formation, foam, technological factors, concrete.

Introduction

Retention of properties of a foam obtained after surfactant species introduction in concrete mix in the presence of sand grains and cement is one of the crucial criteria in porous concrete technology. A number of technological factors affects the properties of surfactant water solution foam systems, i. e. foam formation ability, foam stability and dispersion. These factors are composition (content of cement, sand, foam stabilizers, and some additives), concentration, and temperature of surfactant water solutions; concrete mixer operating conditions, etc.

At first our studies of technological factors influence on foam systems properties were performed using model systems “water + surfactant species”, “water + surfactant species + sand”, “water+ surfactant species + cement”, “water+ surfactant species + foam stabilizer”, “ water + surfactant species + foam stabilizer + cement”. This enabled us to eliminate the influence of side factors and assess quantitatively the effect of each of the factors on the real systems. Porous formation in a mass was performed in hydrodynamic mixture during 3 min at the rate of the mixer rotation providing Reynolds criterion *Re* = 23 (this optimum was obtained in special studies).

Foam formation ability of surfactant water solutions can be evaluated [1] with the aid of height of foam column. This property is connected with surface tension of solution. The surface tension of surfactant water solutions decreases with increase in their concentration reaching its minimum at critical concentrations of micelle formation. The highest foam forming ability of surfactant water solutions corresponds to the lowest values of surface tension in most cases.

The studies were carried out using surfactant water solutions “Penostrom”. Penostrom is the mix of anionic biodegradated hardly-combustible nonexplosive compounds which fall into environmentally low-hazard substances of IV hazard class. Obtained dependences of surface tension of systems “water+ surfactant species”, “water+ surfactant species +sand” and “water+ surfactant species +cement” on surfactant species concentrations are shown in Fig. 1.

Analysis of the dependences indicates that reduction in surface tension of surfactant water solution Penostrom in each system occurs as surfactant species concentrations increase. In this case influence of cement and sand on surface tension and foam formation ability is different. Surface tension and critical concentration of micelle formation of solutions in system “water + surfactant species + sand” are the same as in system “water + surfactant species”, and their foam formation ability isn’t changed. But considerable increase of solution surface tension occurs in system “water+ surfactant species + cement”. Critical concentration of micelle formation correspondingly shifts to field of high values (from $C_{кр.1,2}$ = 0.12 % to $C_{кр.3}$ = 0.35 %). In line with colloidal chemistry concepts it can be concluded that curves discontinuities (Fig. 1) are connected with saturated adsorption layer formation at the boundary “water — air”. Critical concentration of micelle formation has not been changed in system “water + surfactant species + sand” in comparison with system “ water + surfactant species” for additional adsorption of surfactant species molecules at the surface of negatively charged sand grains doesn’t occur. By contrast, a number of surfactant species molecules adsorbs on cement grains in system “water + surfactant species +cement”, that is why critical concentration of micelle formation takes place when surfactant species consumption is large.

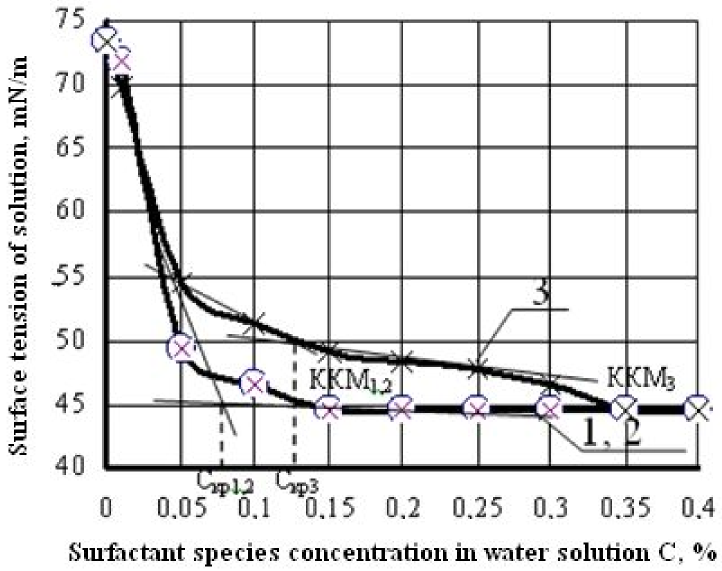

Fig. 1. Graphs of dependences of surface tension in systems “water+ surfactant species”, “water+ surfactant species +sand” and “water+ surfactant species +cement” on surfactant species concentration “Penostrom”:
1, 2 – systems “water+ surfactant species” and “water+ surfactant species +sand”;
3 — system “water+ surfactant species +cement”

It is known [2…6, etc.] that it is important to fit optimal values of concentrations and temperatures in surfactant water solution to obtain maximum stable foam. Studies of dependences of foam stability on concentration at different temperatures of surfactant water solution showed (Fig. 2) that optimal concentration of surfactant water solution “Penostrom” in system “water+surfactant species “ which provides the best foam stability regardless of temperature conforms to critical concentration of solution micelle formation (0.15 %). Slight reduction in foam formation ability of solution with further increase of surfactant species concentration may be caused by loss of surfactant species molecules diffusion rate in its surface layer due to molecules integration into micelles.

Researches on influence of temperature factor on foam formation ability of surfactant species showed (Fig. 3) that the best result is achieved at the temperature of surfactant solution “Penostrom”, equal to 5 ºC. Reduction in foam stability when temperature of solution increases may be governed by enhancement of thermal vibrations of adsorbed molecules, which attenuate mechanical strength of surface layer generated by foam former molecules [1]. It has been proved by studies of foam forming solution viscosity which decreases when temperature increases. Consequently, it is little point in raising the temperature of Surfactant water solution above 20 ºC when obtaining stable foam system.

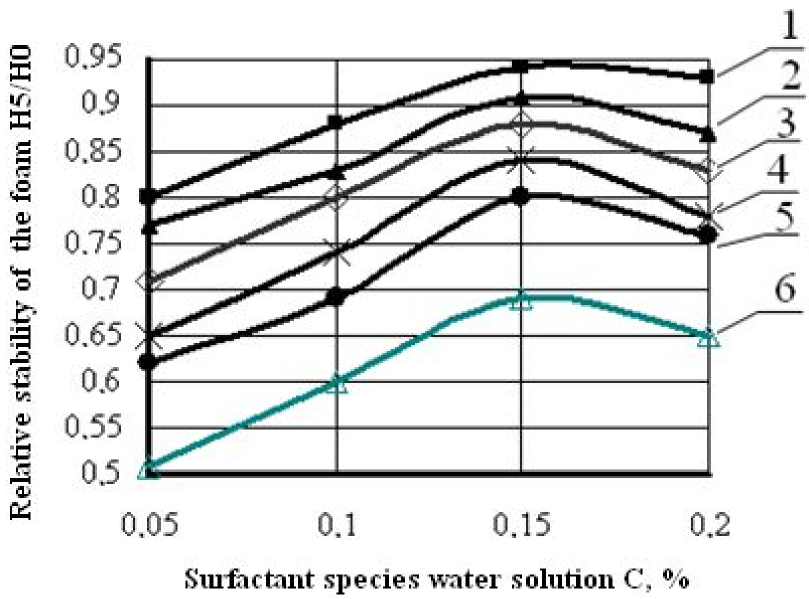

Fig. 2. Graph of dependences of foam structure relative stability in the system "water+surfactant species" on surfactant water solution concentration: H_0 is the initial height of foam column, H_5 is the height of foam column in 5 min after stirring; surfactant water solution temperature t_j, ºC: 1 — 5; 2 — 10; 3 — 20; 4 — 30; 5 — 45; 6 — 70

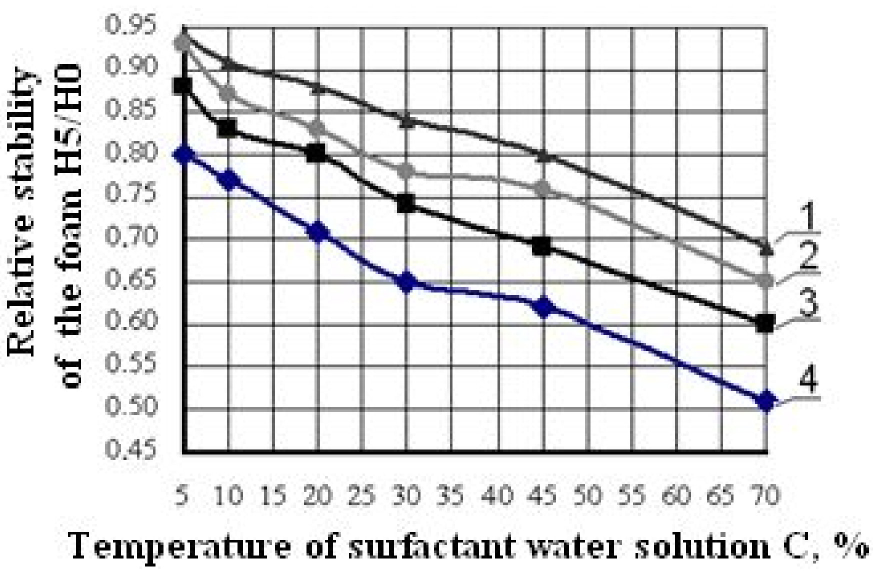

Fig. 3. Graph of dependence of relative stability in the system "water+ surfactant species" on water solution temperature; water solution concentration C_i, %: 1 – 0.15; 2 – 0.20; 3 – 0.10; 4 – 0.05

Of late years not only carboxymethyl cellulose, casein glue, liquid glass, artificial resins, but latex as well are used as foam stabilizer to increase strength properties of porous concrete [6]. We examined latex of new type (БСНК-20/20) as a stabilizer which is produced by Voronezh synthetic rubber plant. Graphs of dependences of latex БСНК-20/20 influence on surface tension (foam-forming ability) of surfactant water solution in the systems “water + surfactant species + foam stabilizer” and “water + surfactant species + foam stabilizer + cement” are shown in Fig. 4.

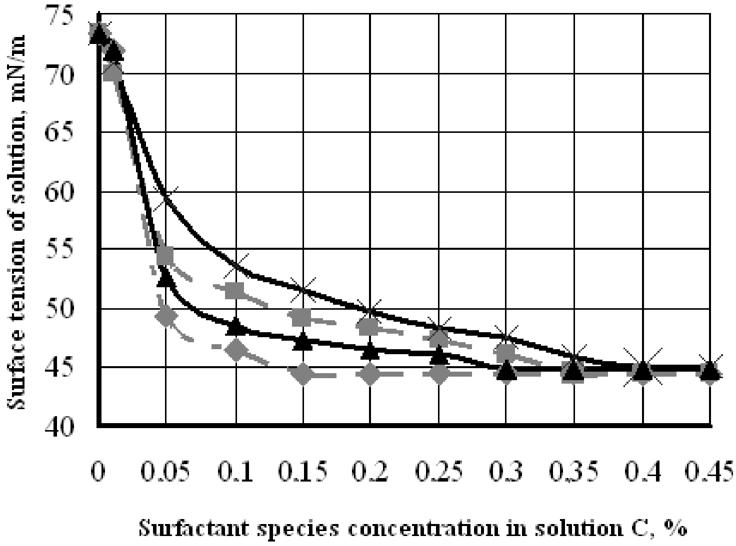

Fig. 4. Graphs of dependences of surface tension of the system “ water + surfactant species” and “ water + surfactant species + cement” on latex БСНК addition– 20/20; Surfactant species concentration in solution C, %: 1 – system “water + surfactant species + cement”; 2 – system “ water + surfactant species”; 3 – system “water + surfactant species + latex + cement”; 4 – system “water + surfactant species + latex”

It has been found experimentally that modification of surfactant water solutions with the aid of high-carboxylated latex increases both their surface tension and critical concentration of micelle formation. The critical concentrations of micelle formation of solutions increase from 0.15 % in system “water + surfactant species” to 0.30 % in system “water + Surfactant species + latex” and from 0.35 % in system “water + Surfactant species + cement” to 0.40 % in system “water + Surfactant species + latex + cement”. Subject to stability of foam structure this data should be considered as adverse ones. But final result turned out to be beneficial (Table).

Table

Relative stability of the foam of surfactant water solution

Surfactant species mass fraction and polymer ratio	Relative stability of the foam H_5/H_0
1: 0.0	0.88
1: 0.5	0.95
1: 1.0	0.92
1: 1.5	0.90
1: 2.0	0.85

In our opinion, it is due to redistribution of Surfactant species molecules in modified solutions. They can be partially adsorbed by hydrocarbon radicals in hydrophobic areas oa latex particles surface.

Furthermore, partial chemical adsorption of COO^- carboxyl groups of polymer and ions of cement particles (Ca^{2+}) with formation of insoluble salts may occurs in system “water + Surfactant species + latex + cement”. It may leads to increase in strength properties of modified porous cement-sand system. When concentration of modified surfactant water solution in system “water + surfactant species + latex” increases from 0.15 % to 0.30 % and in system “water + surfactant species + latex + cement” from 0.35 % to 0.40 % their surface tension decreases and practically approximates to surface tensions for model systems “water + Surfactant species” and “water + Surfactant species + cement”, respectively.

This fact indicates that saturation of modified solutions surface layers with molecules of surfactant species and latex (fields KKM_2 and KKM_4) completes with an increase in modified solutions concentration. Inasmuch as latex application provides increase in foam relative stability, this fact should be taken into account when selecting porous concrete mixes makeups, and it is particularly suitable for mixes of low density.

Conclusion

Thus, optimization of technology factors affecting the properties of the gas-filled building systems foam enables to control the porous concrete structure of any mineral composition.

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