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## Impact of foamed matrix components on foamed concrete properties

V N Tarasenko

Shukhov State Technological University, Belgorod

E-mail: vell.30@mail.ru

**Abstract.** The improvement of the matrix foam structure by means of foam stabilizing additives is aimed at solving the technology-oriented problems as well as at the further improvement of physical and mechanical properties of cellular-concrete composites. The dry foam mineralization is the mainstream of this research. Adding the concrete densifiers, foam stabilizers and mineral powders reduces the drying shrinkage, which makes the foam concrete products technologically effective.

### 1. Introduction.

The polymeric latex compounds with their bonding and reinforcing properties have been known for years [1 – 4]. Polymerizing into the cement structure, latex builds the complex organic reinforcement. Based on the studies provided, a hypothesis was proposed about the increasing the structural-mechanical barrier of the Penostrom, a foam generating agent, by means of synthetic polymeric additives. The purpose of adding the latex into the foam concrete was to enhance the foam bubble structure which resulted in the decreased destruction of bubbles when adding the cementing components as well as in the improvement of the physical and mechanical properties of the foam concrete.

### 2. Materials and methods

The modification of the foam generating agent was carried out with the BS-50A, BS-65 and SKS-50GPS synthetic polymeric latex.

As it is shown in Tables 1 and 2, adding the latex into the foamer solution significantly changed the foam properties: the foamer expansion rate at low concentration was increased as well as the foam stability was doubled.

**Table 1.** The expansion rate of foams produced with modifying agents

Foamer concentration, mass %	Latex	Latex concentration, mass %					
		0	0.0002	0.0004	0.001	0.002	0.005
0.080	BS-50A		7.0	11.0	9.0	8.3	8.5
	BS-65	4.6	9.0	11.0	8.5	8.5	8.3
	SKS-50GPS		7.0	11.0	9.0	9.2	9.0
0.125	BS-50A		6.7	8.2	6.3	5.8	5.8
	BS-65	5.0	7.0	8.0	5.8	5.8	5.8



	SKS-50GPS		6.5	7.5	5.9	5.8	5.8
	BS-50A		11.0	11.0	11.0	11.0	10.5
0.250	BS-65	11.0	11.0	11.0	11.0	11.0	10.5
	SKS-50GPS		11.0	11.0	10.5	10.5	10.5
	BS-50A		15.0	15.0	15.0	15.0	15.0
0.500	BS-65	15.0	15.0	15.0	15.0	15.0	15.0
	SKS-50GPS		15.0	15.0	15.0	15.0	15.0

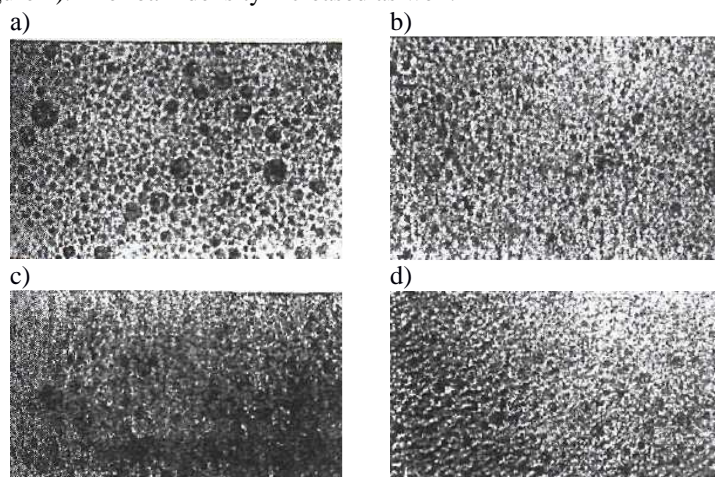
After adding the BS-50A and BS-65 latex, the surface tension of the foamer solutions was near to the surface tension of the reference solutions. Some differences in the surface tension values were detected after adding the SKS-50GPS latex.

**Table 2.** Stability of foams produced with modifying agents, hours-minutes

Foamer concentration, mass %	Latex	Latex concentration, mass %					
		0	0.0002	0.0004	0.001	0.002	0.005
0.080	BS-50A		1-30	2-00	2-10	2-15	2-13
	BS-65	1-20	2-10	2-30	2-38	2-33	2-40
	SKS-50GPS		2-40	2-30	2-40	2-45	2-40
0.125	BS-50A		2-10	2-13	2-13	2-27	2-23
	BS-65	1-22	2-15	2-30	2-40	2-48	2-42
	SKS-50GPS		2-20	2-22	2-21	2-18	2-25
0.250	BS-50A		2-40	2-45	2-25	2-46	2-48
	BS-65	1-41	2-40	2-35	2-38	2-29	2-47
	SKS-50GPS		2-50	2-56	3-10	3-32	4-00
0.500	BS-50A		3-50	3-45	3-40	3-40	3-44
	BS-65	3-40	3-30	3-35	3-23	3-20	3-00
	SKS-50GPS		3-35	3-10	3-00	3-00	3-10

### 3. The study of the modified foam matrix structure.

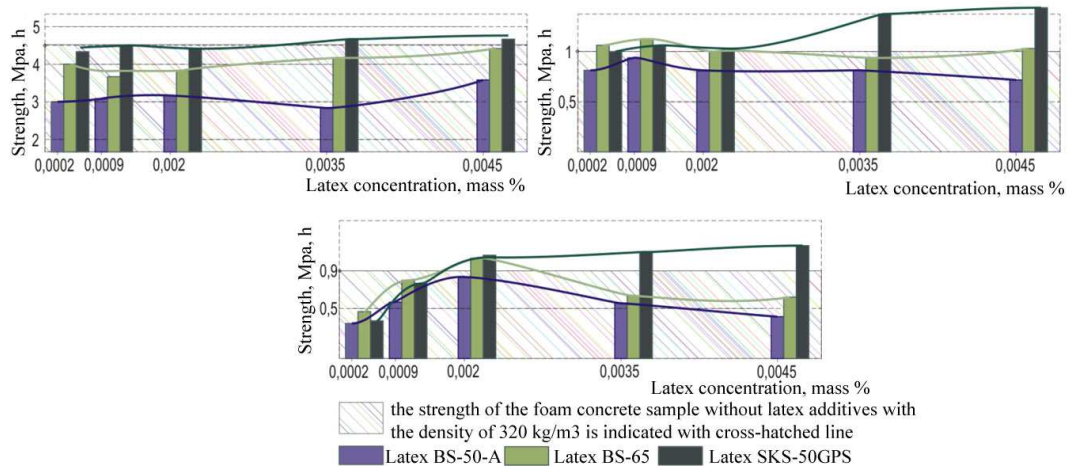
Using the fine-cell foam is one of the crucial techniques to improve the structure and the physical and mechanical properties of the foam concrete. As this research revealed, the foam modification resulted in high dispersion (Figure 1). The foam density increased as well.



**Figure 1.** Images of foams: a – without additives; b – with addition of BS-50-A; c –with addition of BS-65; d – with addition of SKS-50GPS (x 2.5 zoom).

The bubble size of the foams with addition latex was changed from 0.1 mm to 1 mm, when the bubble size of the modified foam agent was from 0.5 to 3 mm. The obtained results demonstrated the efficiency of the modifying additives which improved the foam properties.

To study the strength and density dynamics of concrete with different ratio of polymeric additives, the reference samples based on the foamer solution without latex additives. The results of the experiments are presented in Figure 2.



**Figure 2.** Variation of the foam concrete density and strength at various water-cement values and the latex concentration: a – when the water-cement ratio was 0.45; b - when the water-cement ratio was 0.6; c - when the water-cement ratio was 0.9.

As the study of the density and strength of foam concrete without modifying additives demonstrated, when the latex concentration is increased higher than 0.0035...0.0045 %, the density of samples as well as their strength increase. The type of latex hardly impacted the foam concrete properties. In fact, the increase of water – cement ratio results in the foam breaking decrease when obtaining the foam concrete suspension. This technique is used to produce the foam concrete of low density.

The stress-strain properties of the foam concrete samples are presented in Table 3. The obtained results revealed that the small amount of modifying additive reduced the foam concrete shrinkage by 10 – 30%. It was probably due to the viscous fluid – air interface film which prevented the samples from drying out and, as a result, from reducing the shrinkage moisture during the initial maturity. The setting time and the hardening rate of cement had the critical impact on the foam concrete structure. The impact of the polymeric additives on the properties of the water-cement mixture of normal consistency and setting time was studied using the GOST 310.2-310.3-76 National Standard techniques.

**Table 3.** The stress-strain properties of the foam concrete based on modifying foam-generating agents

Water – cement ratio	Latex	Latex concentration, mass %	Density of a set of six samples, kg/m <sup>3</sup>	Shrinkage, mm/m	Shrinkage strain reduction, %
0.45	without additives	0	800	2.36	-
	BS-50A	0.003	820	2.13	9.74
	BS-65	0.003	790	2.01	14.8
	SKS-50GPS	0.003	690	2.10	11.0
0.50	without additives	0	440	2.58	-
	BS-50A	0.003	450	1.82	29.4
	BS-65	0.003	465	1.79	30.6
	SKS-50GPS	0.003	470	1.80	30.2
0.60	without additives	0	440	3.10	-
	BS-50A	0.003	280	2.15	30.6
	BS-65	0.003	275	2.23	28.0
	SKS-50GPS	0.003	260	2.16	30.3

Adding the non-modified foamer into the solution reduced the normal density by 2%, i.e. the non-modified foamer provides the flexibilizing effect (the initial setting of the water-cement mixture was reduced by 30 minutes both with normal density and with the water-cement ratio of 0.45).

Addition of latex to the water – cement solution reduced the normal density by 3.2...4.4 % in comparison with the reference mixture. Moreover, the reduction of the setting time by 30...40 minutes was detected.

#### 4. Conclusion

The study of foaming in a two-phase system which contains the synthetic surface-active agents revealed that using the mixtures of more than one surface active agent with different functionality (carboxylate and sulphonic acid groups) provided the increased efficiency of a foam generating agent.

The foam concrete based on a composite foam generating agent demonstrated better physical and mechanical properties compared to the samples based on a single surface-active agent.

The significant increase of efficiency was obtained by adding the water-soluble synthetic and natural polymers (protein hydrolyzates with the concentration of 0.004% and latex with the concentration of 0.0002...0.0009 %) into the solution of synthetic low-molecular foamer.

The relation of the foam concrete density and the concentration of synthetic foamers could be approximated by a flat-top parabolic curve. This linear relation is negative for the Neopor foamer: the higher the concentration is, the lower the density is. Here, the optimal region of average density (400...700 kg/m<sup>3</sup>) for various foamers falls within the following concentration range: within 0.06...0.1 % for AOS, within 0.04...0.07 % - for TEAS, within 0.03...0.08 % - for Penostrom, and within 0.5...0.1 % - for Neopor.

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