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CELLULAR AND FINE-GRAINED CONCRETE BASED ON SILICA WITH DISPERSED REINFORCEMENT

Abstract. The results of studies of the physical and mechanical properties of heat-efficient foam concrete, as well as fine-grained concrete, are summarized. The materials are made on the basis of silica microfibre. The percentage of fibers varies within the prescribed limits, and they must be prepared from different materials. The determination of physical and mechanical properties corresponds to GOST 180-2012. Thus, it was found that the optimal content of basalt and steel fiber fibers in foam concrete samples is about – 2%, polypropylene – 3%. The compressive strength of foam concrete samples increases by 2.4-3.6 times, and the bending strength by 2.0-4.2 times, depending on the type of fiber. Sufficiently high physical and mechanical properties were obtained from fine-grained concrete based on basalt and polypropylene fibrous fibers.

Keywords: basalt fiber, polypropylene fiber, steel fiber, silica, non-autoclaved fibropen concrete, fine-grained fibroconcrete.

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Introduction. Such fine ultrafine fillers lead to high strength characteristics. This applies to heavy and cellular concretes, but at the same time there is a decrease in the density of fine-grained concrete [1-3].

Fine filler in concrete creates prerequisites for the formation of deformations and cracking.

Analyzing the literature and patent data, we came to the conclusion that dispersed reinforcement can solve the problem of increasing strength indicators during bending and compression. Obviously, dispersed reinforcement solves the problem of reducing the fragility of the destruction of building material [4-16].

The presence of a reinforcing mesh reduces cracking in concrete by 6%, whereas metal fiber – 25%, and, accordingly, polymer fibers - 90%.

The presence of fiber in the concrete body provides volumetric hardening, which cannot be said about traditional reinforcement. Dispersed reinforcement allows lower costs for building materials, while achieving sufficiently high physical and mechanical parameters in the production process. Also, importantly, labor costs are also minimal.

The purpose of this work is to obtain by experimental methods the optimal fiber content in heat-efficient foam concrete and fine-grained concrete, based on silica, to obtain a material with high strength characteristics.

Conditions and methods of research.

The following materials were used in the research:

- Portland cement of the CEM I 52.5 R brand manufactured by Chimsa (Turkey);
- portland cement of the CEM I 42.5 N brand produced by Angarsk Cement JSC (Angarsk);
- microsilicon from filters of dust catchers of JSC "Silicon" (Shelekhov);
- polycarboxylate-based hyperplasticizer MC-PowerFlow-3100 (Germany);
- synthetic foaming agent Penta Surfactant 430 (grade A);
- polypropylene fiber (Fig. 1, a);
- basalt fiber (Fig. 1, b);
- steel fiber (Fig. 1, c).

a b c

a – polypropylene fiber; b – basalt fiber; c – steel fiber

Figure 1. Types of fibers

Table 1

Physical and mechanical characteristics of fiber fibers from different materials

Fiber	True density, g/cm^3	Tensile strength, MPa	Modulus of elasticity, MPa	Elongation at break, %	Fiber diameter, microns
Polypropylene	0.91	150-600	35000	20-150	10-25
Basalt	2.60	3500	$\geq$ 75000	3.2	13-17
Steel	7.80	600-1500	190000	3-4	500-1200

The physical and mechanical characteristics of fiber fibers made of different materials are given in Table 1.

The research methodology was as follows. Foam concrete mixture for D500 grade foam concrete of control composition (without fiber) and with fiber content was prepared according to classical technology: a mixture of Portland cement (CEM I 42.5 N), silica and fiber (or without fiber), sealed with water with hyper plasticizer, and foam (water + foaming agent) were prepared separately. Then everything was mixed until a homogeneous mass was obtained.

The concrete mixture for the production of fine-grained concrete samples was prepared manually: the required amount of Portland cement (CEM I 52.5 R), silica and fiber were mixed together in a dry state, then the mixture was sealed with water with a hyperplasticizer dissolved in it and mixed to a homogeneous consistency. The ratio of Portland cement to micro silica was assumed to be constant equal to 1:1. The percentage of fiber of various types in the composition of the concrete mixture varied from 1 to 3% of the mass of solids [15-16].

The water-solid ratio was 0.5 for the manufacture of fine-grained concrete and 0.55 for foam concrete. The hyperplasticizer was injected into the foam concrete mixture in an amount of 0.46%, into the concrete mixture – 0.2% of the mass of solids.

Samples of 40×40×160 mm in size were formed from prepared concrete mixtures with different amounts and types of fiber.

Table 2

Physical and mechanical characteristics of fibropenobetons

The amount of fiber, % by weight of solids	Average density of dry samples, pm, g/cm^3	Compressive strength, R_{sj}, MPa	Bending strength, R_i, MPa
Fibropen concrete with basalt fiber content			
1	0,.458	0.29	0.47
2	0.576	1.99	2.1
3	0.482	0.64	1.16
Fibropen concrete with steel fiber content			
1	0.451	0.25	0.29
2	0.542	0.65	0.61
3	0.514	0.43	0.42
Fibropen concrete with polypropylene fiber content			
1	0.403	0.09	0.12
2	0.477	0.42	0.54
3	0.561	1.27	1.17
Control composition (without fiber content)			
–	0.471	0.45	0.41

Table 3

Physical and mechanical characteristics of fine-grained fiber concrete

The amount of fiber, % by weight of solids	Average density of dry samples, pm, g/cm^3	Compressive strength, R_{sj}, MPa	Bending strength, R_i, MPa
Fine-grained fiber concrete with basalt fiber content			
1	1.149	21.47	4.16
2	1.133	27.1	4.6
3	1.133	22	5.2
Fine-grained fiber concrete with steel fiber content			
1	1.109	17.62	3.47
2	1.135	20.3	5
3	1.099	13.9	5.2
Fine-grained fiber concrete with polypropylene fiber content			
1	1.116	15.20	3.39
2	1.140	25	4.7
3	1.152	22.7	5.25
Control composition (without fiber content)			
–	1.150	24.75	3.35

After the expiration of the time, namely 28 days, hardening under normal conditions, drying was continued at a temperature of 105 = 5°C. Based on GOST 10180-2012 "Concrete. Methods for determining strength from control samples", conducted the necessary tests of material samples, that is, tests to determine compressive strength and bending strength.

Research results and discussions. The experimental data obtained are shown in the corresponding tables and are recorded in the figures below.

In the course of the work, well-known indicators such as specific strength (R_m) or coefficient of structural quality (KK) were used. The above parameters are suitable for this work, namely to determine the effectiveness of reinforcement of thermal insulation foam concrete

The ratio of the compressive strength Rj or the bending strength R of the material to d is called the ratio of the compressive strength Rj or the bending strength R of the material to its relative density.

The relative density is called a dimensionless quantity, which is equal to the ratio of the average density of the material (m) to the density of water. At a temperature of 4°C (w = 1 g/cm^3). Thus, the relative density is equal to the average density of the material.

In Figure 2 it can be seen that the greatest strength characteristics of foam concrete using basalt fiber fibers were obtained when they were contained in an amount of 2% by weight of solids: the specific compressive strength increased 3.6 times, and the specific bending strength – 4.2 times compared with the control composition (without fiber).

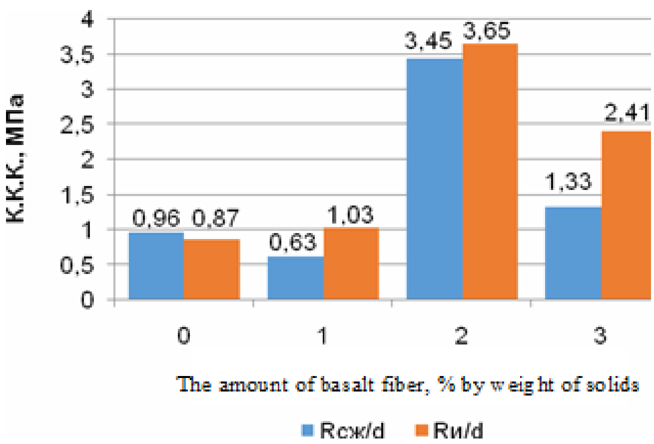

Figure 2. Dependence of the compressive and bending strength of D500 foam concrete on the amount of basalt fiber

According to the histogram shown in Figure 3, it can be seen that the optimal amount of steel fiber fibers in foam concrete is 2% of the mass of solids, while the compressive strength increased by 25%, and the specific bending strength increased by 30% compared with the control composition.

Analyzing the results of experimental data, we come to the following conclusion: the content of steel fiber fibers 2%, leads to an increase in compressive strength by 25%, and bending strength by 30%. The conclusion was made on the basis of comparative characteristics with control samples.

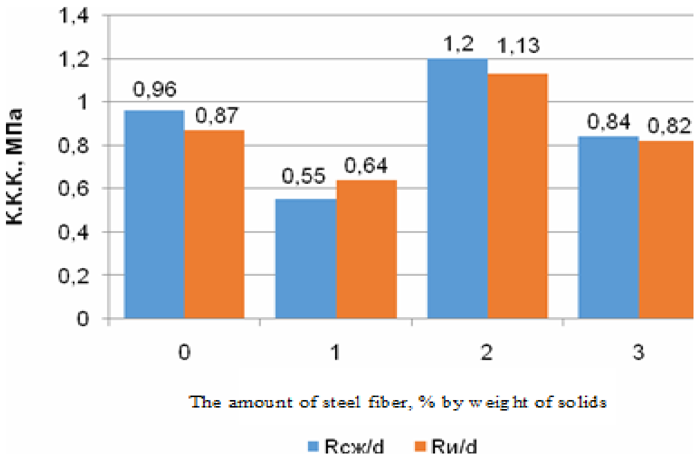

Figure 3. Dependence of the compressive and bending strength of D500 foam concrete on the amount of steel fiber

The data presented in Figure 4 show that the greatest strength characteristics of foam concrete using polypropylene fiber fibers were obtained when they contained 3% of the mass of solids: specific compressive and bending strengths increased 2.4 times compared with the control composition.

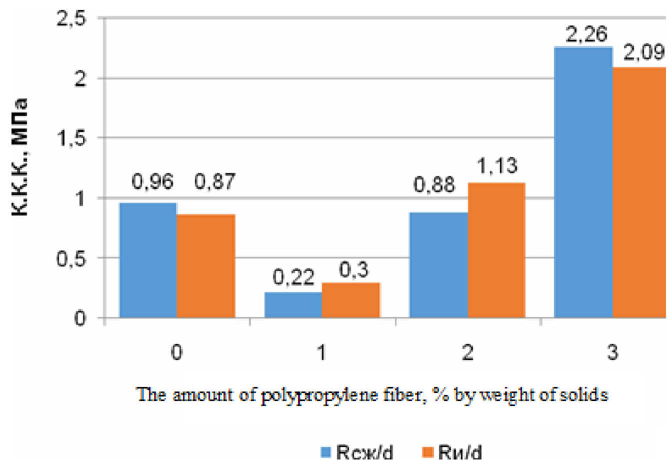

Figure 4. Dependence of the compressive and bending strength of D500 foam concrete on the amount of polypropylene fiber

The experimental results of the studies recorded in Figure 4 eloquently indicate high rates when using 3% polypropylene fiber fibers. The strength of the tested samples increased by 2.4 times.

The use of basalt fiber in the composition of fine-grained concrete in an amount of 2% by weight of solids (Fig. 5).

It contributes to an increase in its compressive strength by 9.5% and bending strength by 37.3% compared to control samples (without fiber).

The experimental results of the studies recorded in Figure 5 eloquently indicate high rates when using 2% basalt fiber. The strength of the tested samples increased by 9.5 times, and the bending strength by 37.3%.

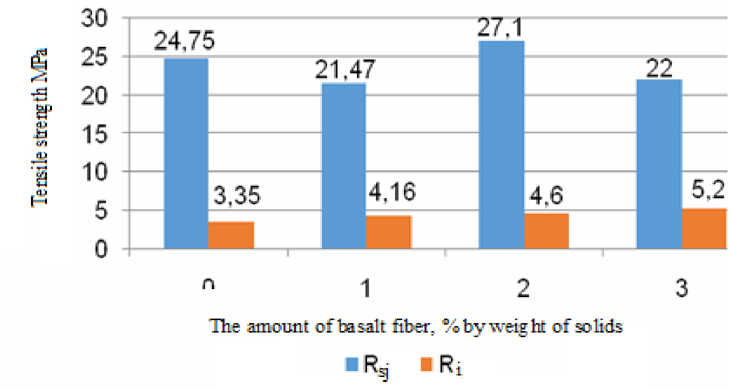

Figure 5. Dependence of the compressive and bending strength of fine-grained concrete on the amount of basalt fiber

Dispersed reinforcement of fine-grained concrete with steel fiber fibers in an amount of 2% by weight of solids reduces its compressive strength by 18%, but at the same time the bending strength increases by 49.3% relative to control samples (Fig. 6).

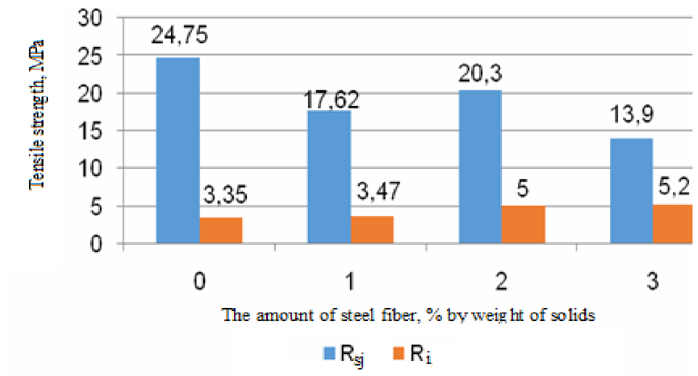

Figure 6. Dependence of the compressive and bending strength of fine-grained concrete on the amount of steel fiber

A further increase in the amount of steel fiber in fine-grained silica-based concrete leads to an even greater decrease in the compressive strength, but the bending strength increases slightly.

It is possible that the loss of compressive strength of concrete during the introduction of steel fiber fibers is related to their diameter. The diameter of steel fibers is larger than that of basalt and polypropylene fibers (Table 1), respectively, the percentage of reduction in compressive strength in concretes with steel fiber is higher than in concretes containing basalt and polypropylene fibers (Figs. 5-7).

The use of polypropylene fiber in the composition of fine-grained concrete in an amount of 2% by weight of solids (Fig. 7) contributes to a slight increase in its compressive strength (1%), the increase in bending strength is 40.3% compared to samples without fiber. A further increase in the amount of polypropylene fiber leads to an increase in the bending strength by 56.7% and a decrease in the compressive strength by 8.3%.

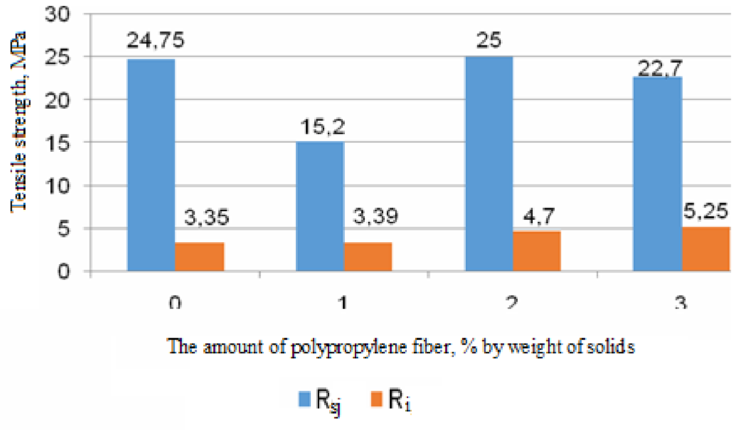

Figure 7. Dependence of the compressive and bending strength of fine-grained concrete on the amount of polypropylene fiber

Conclusion. It has been experimentally established:

- that the optimal amount of basalt and steel fiber fibers in foam concrete is 2% of the mass of solids, polypropylene – 3%. At the same time, the compressive strength of samples using basalt fiber increases by 3.6 times, and the specific bending strength by 4.2 times, for samples containing steel fiber, the specific compressive strength increases by 25%, and the specific bending strength by 30%, for samples with polypropylene fiber, the specific strength at compression and bending increase by 2.4 times compared to the control samples;

- the optimal amount of basalt, steel and polypropylene fibers in the composition of fine-grained concrete is 2% by weight of solids. At the same time, the use of basalt and polypropylene fiber fibers leads to an increase in its compressive strength by 9.5% and 1% and an increase in bending strength by 37.3% and 40.3%, respectively, the use of steel fiber reduces the compression strength by 18%, but increases the bending strength by 49.3%.

Thus, all three types of fiber contribute to an increase in bending strength. However, the highest values of specific bending and compressive strength of heat-insulating foam concrete based on silica were obtained using basalt fiber fiber, therefore its use in foam concrete is preferable compared to the other two. For fine-grained silica-based concrete, the best results were obtained using basalt and polypropylene fiber fibers.

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ДИСПЕРСТІ АРМАТУРАСЫ БАР ТОРЛЫ ЖӘНЕ ҰСАҚ ТҮЙІРШІКТІ КРЕМНИЙ НЕГІЗІНДЕГІ БЕТОН

Аңдатпа. Жылу тиімді көбік бетонының, сондай-ақ ұсақ түйіршікті бетонның физикалық-механикалық қасиеттерін зерттеу нәтижелері қарастырылған. Материалдар кремний диоксиді микроталшық негізінде жасалған. Талшықтардың пайызы белгіленген шектерде өзгереді және олар әртүрлі материалдардан жасалуы керек. Физикалық-механикалық қасиеттердің анықтамасы ГОСТ 180-2012 сәйкес келеді. Осылайша, көбік бетон үлгілеріндегі базальт пен болат талшықтарының оңтайлы мөлшері шамамен – 2%, полипропилен – 3% екендігі анықталды. Көбік бетон үлгілерінің қысу беріктігі талшықтың түріне байланысты 2,4-3,6 есе, ал иілу беріктігі бойынша 2,0 – 4,2 есе артады. Базальт және полипропилен талшықтары негізінде ұсақ түйіршікті бетоннан жеткілікті жоғары физикалық-механикалық қасиеттер алынды.

Тірек сөздер: базальт талшығы, полипропилен талшығы, Болат талшық, кремний диоксиді, автоклавсыз фибробетон, ұсақ түйіршікті фибробетон.

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ЯЧЕИСТЫЙ И МЕЛКОЗЕРНИСТЫЙ БЕТОН НА ОСНОВЕ КРЕМНЕЗЕМА С ДИСПЕРСНЫМ АРМИРОВАНИЕМ

Аннотация. Обобщены результаты исследований физико-механических свойств теплоэффективного пенобетона, а также мелкозернистого бетона. Материалы изготовлены на основе кремнеземного микроволокна. Процентное содержание волокон варьируется в установленных пределах, и они должны быть приготовлены из различных материалов. Определение физико-механических свойств соответствует ГОСТ 180-2012. Таким образом, было установлено, что оптимальное содержание базальтовых и сталеволокнистых волокон в образцах пенобетона составляет около – 2%, полипропиленовых – 3%. Прочность образцов пенобетона на сжатие увеличивается в 2,4-3,6 раза, а прочность на изгиб – в 2,0-4,2 раза в зависимости от вида волокна. Достаточно высокие физико-механические свойства были получены у мелкозернистого бетона на основе базальтовых и полипропиленовых волокнистых волокон.

Ключевые слова: базальтовое волокно, полипропиленовое волокно, стальное волокно, кремнезем, неавтоклавный фибробетон, мелкозернистый фибробетон.