Natalya Lukuttsova, Evgeniy Karpikov, Evgeniy Degtyaryov

INTEGRATED MICRODISPERSE ADDITIVE AND CONCRETE ON ITS BASIS

Introduction

Getting concretes of new generation, and also possessing special properties, is impossible without using high-quality, high-strength and homogeneous in its properties binder, without the introduction of effective technological solutions; without using special additives for the modification of Portland cement and concrete mixes. Additives (chemical, mineral, synthetic and natural modifiers) are introduced into the raw sludge while burning clinker, they are also added during the secondary clinker grinding and introduced into the concrete and mortar mixes.

The study of silica microdispersions, having little research experience as well as their influence on the properties of fine-grained concretes is of great interest nowadays. Today somewhat less appears in literature concerning available technologies for obtaining stable micropowders for the construction industry.

Currently, there exists the problem of using substandard silica sands. These sands are intended primarily for reducing the cost of constructional projects and are very often used in foundation work of zero cycle. The main difference of the substandard sand from ravine or bank sand is that it has a low Abram's fineness modulus and therefore it cannot be used for any engineering works, for example, for the production of concrete. However, it is perfectly suitable for the construction of roads, or backfill refilling of trenches, and taking into account its low price it is an ideal material for low-budgetary projects [1].

The aim of the research is to develop the effective integrated microdisperse additive for getting fine-grained concrete of new generation.

The scientific novelty of this research is that it justifies the possibility of obtaining functional fine-grained concrete with the improved physical and technical properties by adjusting its structure with the help of developed microadditives.

1. Experimental part

The increased total aggregate surface area of fine-grained concretes raises the water requirement and hence, the cement consumption because the solution for providing the desired consistency requires more cement glue. This slightly increases the shrinking deformations, creep and deformability. Fine-grained concrete in comparison with standard concrete is characterized by lower compressive strength, low freeze-thaw resistance and worse bond with steel.

For eliminating these drawbacks of fine-grained concretes and improving their physical and technical indicators there has been developed an integrated microadditive, allowing to use substandard silica sands as a means of complete concrete aggregate.

It is known that plasticizer additives, the introduction of which allows us to control the kinetics of concrete mix structure formation directionally, are especially effective when using industrial wastes and untraditional raw material, which in its turn makes it possible to adjust the basic physical and technical concrete characteristics.

The use of superplasticizers significantly reduces the amount of intergranular space and hence the capillary porosity, which is the determining factor for strength, freeze-thaw and corrosion resistance of concrete [2].

As it is known, microadditives on the basis of crushed finely dispersed silica sand lose their activity with time. Therefore, technical calcium stearate C-17 $C_{36}H_{70}O_4Ca$, increasing the retention cycle, raising freeze-thaw resistance, waterproofness and reducing concrete shrinkage is used to ensure the additive stability [3].

An integrated microdisperse additive was obtained by intergrinding of silica sand, superplasticizer S-3 and water-repelling agent in ball mill. Fraction of total mass of the introduced additives was 1 and 0.5%, respectively.

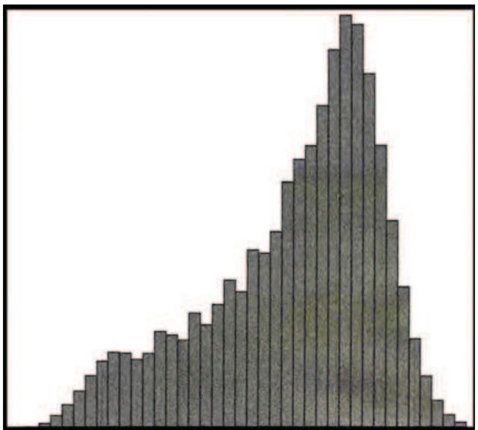
To study the effects of microadditives on the physical and mechanical properties of the fine-grained concrete there were made samples from cement M 500 D20 and silica sand and having size 4×4×16 cm, which hardened under normal conditions.

2. Results and discussion

The researches of the microadditive dispersity were carried out on the laser particle analyzer Microsizer 201. Silica sand, superplasticizer S-3 and calcium stearate ground in ball mill both together and separately for 60 minutes were used as test materials. The obtained results show that the grain distribution diagram of ground silica sand has extremal nature. The maximum number of particles is in the range from 66.4 to 81.1 μm and accounts for 30% of the total weight of the test material (Fig. 1a). When grinding silica sand and additive S-3 together, the maximum number of particles is in fractions from 99 to 121 μm and accounts for 32% of the total mass (Fig. 1b), silica sand and calcium stearate are in fraction from 81.1 to 99 μm with the total mass of 31% (Fig. 1c), silica sand, superplasticizer S-3 and calcium stearate are in fractions from 99 to 121 μm and account for 32% of the total mass correspondingly (Fig. 1d).

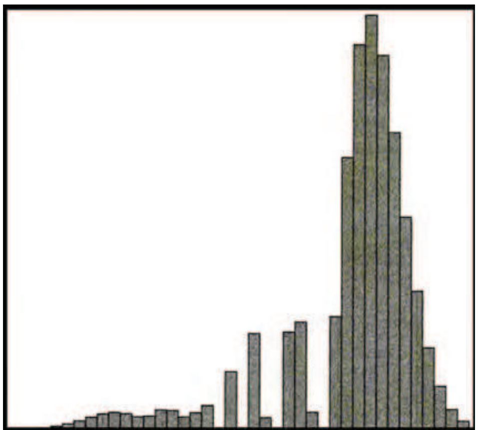
Thus, the distribution of particles of the investigated powders is monofractional. With the introduction of additives S-3 and calcium stearate into silica sand, the particles content of one fraction is maximal and this fact has a positive effect on the characteristics of fine-grained concrete modified by such structure. This can be explained by the fact that during grinding the raw material passes through the stages of destruction of natural agglomerates, partial amorphization of grains with the defects development in them and the formation of heteromineral conglomerates. The degree of resistance of the latter and their number are the factors of quality changes of the technological properties of products [1].

a)



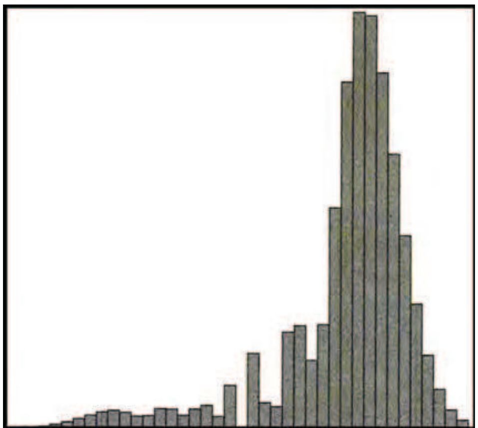
Particle size, D, mkm	Weight fraction, P, %
3.05	10
8.75	20
17.6	30
29.6	40
43.9	50
60.6	60
79.1	70
104	80
147	90
600	100

b)



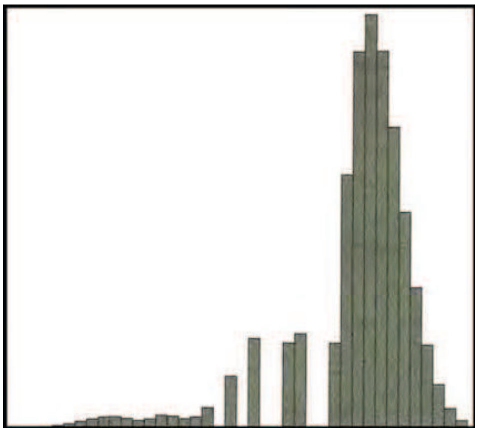
Particle size, D, mkm	Weight fraction, P, %
14.8	10
55.6	20
77.0	30
90.9	40
105	50
121	60
141	70
170	80
220	90
600	100

c)



Particle size, D, mkm	Weight fraction, P, %
16.6	10
46.4	20
67.0	30
80.6	40
94.2	50
110	60
129	70
156	80
205	90
600	100

d)



Particle size, D, mkm	Weight fraction, P, %
16.4	10
67.5	20
83.0	30
96.1	40
110	50
126	60
146	70
175	80
226	90
600	100

Fig. 1. Diagram of the grains distribution: a) silica sand, b) silica sand + additive S-3, c) silica sand + calcium stearate, d) silica sand + additive S-3 + calcium stearate

Compositions of the fine-grained concrete with microdisperse additive on the basis of silica sand and the obtained results are shown in Table 1, as well as in Figures 2 and 3.

TABLE 1

The compositions of the fine-grained concrete

Composition №	Weight [kg]				Content from the sand mass [%]	
	Cement	Sand	Water	Content of the finely dispersed silica sand	S-3	Calcium stearate
Test	0.5	1.5	0.18	–	–	–
1	0.5	1.5	0.18	0.075	1	0.5
2	0.5	1.5	0.18	0.15	1	0.5
3	0.5	1.5	0.18	0.225	1	0.5

As a result of the research on the effect of integrated microadditive on the compression strength it was revealed that dependence is characterized by extremal nature. After 28 days of curing in normal conditions, the maximum strength is achieved while adding microadditive in the amount of 10% from the cement mass and it is 48.94 MPa (Fig. 2a).

a) b)

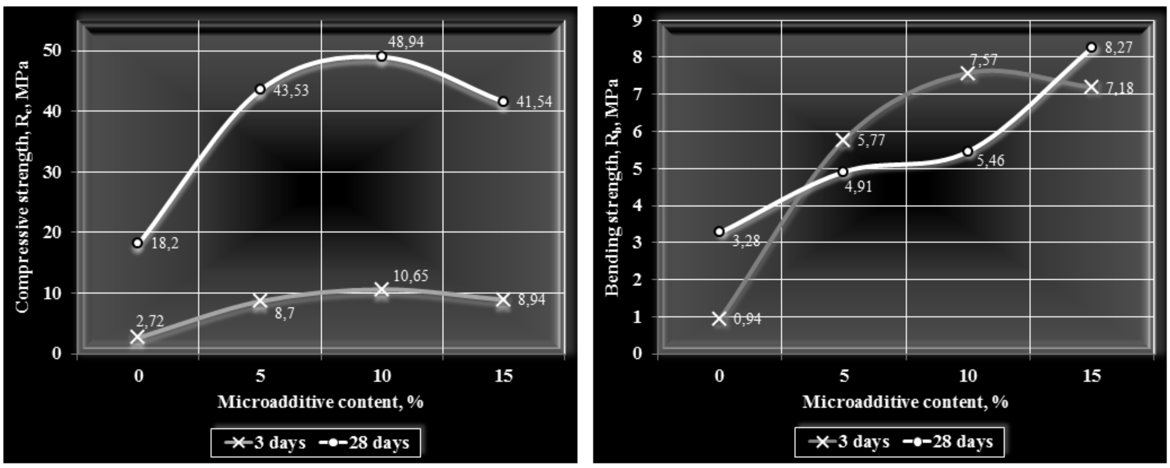


Fig. 2. Tensile strengths of the fine-grained concrete depending on the microadditive on the basis of silica sand content: a) under compression, b) under bending

The bending strength increases proportionately to the microadditive content in the range from 3.3 to 8.3 MPa, that is in 2.5 times. The maximum value of the fine-grained concrete bending strength is observed also at the content of the integrated microadditive in the amount of 10% (Fig. 2b). Research of the fine-grained concrete density demonstrates the same dependence from the microadditive content (Fig. 3a). The increase of the fine-grained concrete density is conditioned by the closer packing of the aggregate grains relative to each other due to the introduction of the integrated microadditive. Further increase of the microadditive content in the fine-grained concrete leads to the structure decompaction and reduces its physical and mechanical characteristics.

a) b)

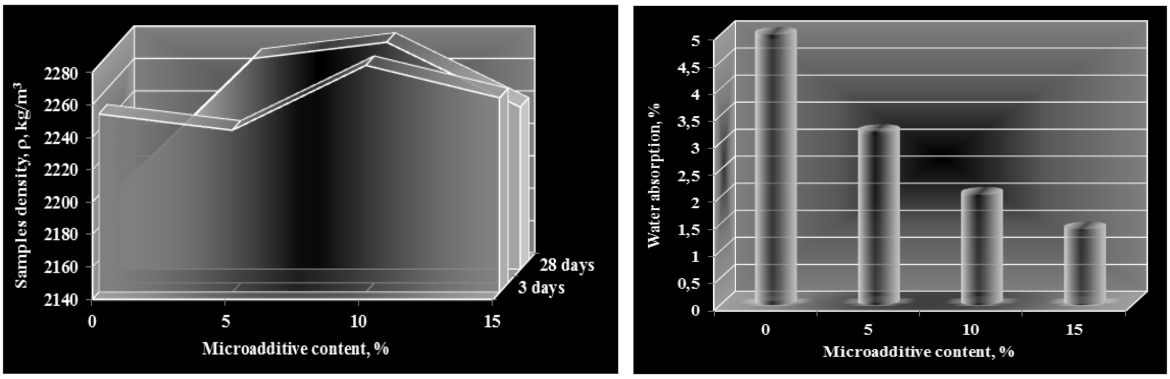


Fig. 3. Dependence of the fine-grained concrete samples from the content of the integrated organic-mineral additive: a) density, b) water absorption

It was also stated that as the content of the integrated microadditive increases, the fine-grained concrete water absorption significantly lowers from 5.1 to 1.4%, that is in more than 3.5 times and with its content equal to 15% it reduces 4 times in comparison with the test composition (Fig. 3b) [3].

The presence of finely dispersed mineral additives affects the mobility of fine-grained mixes. Changes in the duration of the initial pattern formation periods can be explained by the fact that the increase in the degree of filling of cement paste, due to the reduction of plasticity, requires an increase of the water content for obtaining paste of standard consistency. With the increase of water content and accordingly, a reduction in unit volume of the fraction cement binder the setting time increases because water shells become thicker and products of new formations are to fill larger volume for creation of coagulation-crystallization structure.

The introduction of floured additives makes it possible to keep the total volume of cement paste sufficient for filling the sand hollows and aggregate grains coating, to obtain placeable mixtures, to stimulate the increase of water-holding capacity and viability of the fine-grained mixtures [4].

When grinding the feedstock in a ball mill there occurs the decrease of the average particles size and change in their morphology due to the exogenous processes arising from the impact and friction of steel balls and cylinders, and the most significant things are the profound changes in the surface energy values of the minerals structure index.

The mechanism of the processes is as follows. First during the silica crushing there occurs disordering of its crystal lattice, and then during further grinding, just after the destruction of the particles - the formation of amorphous products on their surface. In the direction of the particle depth the layers of crystals are characterized by increasing sizes, and in the center - by the permanent structure. Amorphization, that is obtaining supercooled silica liquid with a high coefficient of viscosity significantly reduces the surface activation energy and increases its reactivity within the distance of 0.5÷1 nm, corresponding to the formation of short range of atoms and molecules ordering.

The surface energy (activation) is the defining characteristic for freshly ground or subjected to only a superficial surface abrasion action particles. Further transition to the thermodynamically stable state contributes to the adsorption of gaseous products from air on the particles, adhering of the fine-grained particles to the crystals surface and the formation of protective films from aqueous solutions of chemical additives.

It is possible to obtain fine-grained concrete with powdered additives or components of different functions during the preparation modes enabling namely the activation of silica surface particles (low grinding, moderate abrasive action, etc.) that is aimed only at increasing the surface energy. However, it is very important in this case to use a very short period (from fractions of seconds to several minutes), when the surface energy has a high value. Calcium stearate, increasing the retention cycle, raising freeze-thaw resistance, waterproof and reducing concrete shrinkage is used to ensure the stability of the additive properties.

It is also necessary to mention that the binder particles are well adsorbed on the activated surface, ultimately increasing the contact area with microfillers, and playing the role of hardening accelerators - the so-called “crystal seeds”.

Conclusion

The carried out research revealed positive changes in the fine-grained concrete microstructure parameters when using the worked out integrated microadditive with the prevaling particles having sizes from 99 to 121 μm. It was established that integrated microdisperse additive implies the possibility of getting products with compressive strength up to 59 MPa, at bending equal to 8.3 MPa, water absorption 1.4%, freeze-thaw resistance more than F75, which proves the effectiveness of its use in the fine-grained concrete.

It was stated that at the content of the integrated microdisperse additive equal to 5÷10% from the cement mass there occurs the reduction of the overall porosity in comparison with the fine-grained concrete with and without additives, being introduced locally. This is due to the structure formation by changing the chemistry of the hydration processes in the presence of finely dispersed, partially amorphous, and therefore more active silica, the component acting as an active mineral additive, binding isolated during the hydration process $Ca(OH)_2$ into the calcium hydrosilicates.

References

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Abstract

There has been developed an integrated microdisperse additive for the production of functional fine-grained concrete on the basis of substandard silica sand. It was established that integrated microdisperse additive implies the possibility of getting products with compressive strength up to 50 MPa, at bending equal to 8.3 MPa, water absorption 1.4%, freeze-thaw resistance more than F75 with its content of $5 \div 10\%$ from the cement weight.

Keywords: concrete, concrete additives, microdisperse additives

Zintegrowane dodatki mikrodyspersyjne i beton na ich bazie

Streszczenie

Opracowano zintegrowane dodatki mikrodyspersyjne do produkcji efektywnego drobnoziarnistego betonu na bazie piasku kwarcowego. Ustalono, że dodatki pozwalają na uzyskanie produktu o wytrzymałości na ściskanie do 50 MPa, na zginanie 8,3 MPa, nasiąkliwości 1,4%, mrozoodporności większej niż F75.

Słowa kluczowe: beton, dodatki do betonu, dodatki mikrodyspersyjne