# FINE-GRAINED CONCRETE BASED ON BINDERS THAT REQUIRE LESS WATER

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**Annotation:** *The widespread introduction of fine-grained concretes (FGCC) into the practice of monolithic housing construction is limited by their low crack resistance due to significant shrinkage. In order to study the processes of structure formation and properties of FGCC, concrete mixtures were made based on quartz sand of medium grain size, dispersed fly ash and an expanding additive. The activity of fly ash increased due to mechanochemical activation, the dispersion of particles was controlled using the method of laser granulometry.*

**Keywords:** *mineral fillers, expansion of cement stone, calcium hydrosulfoaluminate, composite binder, microfiller, structure formation of cement stone, fine-grained concrete.*

## INTRODUCTION

*The need for widespread introduction of fine-grained concrete (FGCC) into construction practice is also due to the fact that in many regions of Uzbekistan there is an acute shortage of high-quality coarse aggregate necessary for the preparation of effective concrete and reinforced concrete structures, and there are no building materials on the market proposals for the supply of multi-fraction aggregates required for the preparation of self-compacting concrete.*

## MATERIALS AND METHODS

*An effective way to eliminate the harmful effect of shrinkage on the structure and properties of FGCC is the use of expanding additives (ED). The introduction of ED into the composition of the binder makes it possible to actively influence the development of the processes of structure formation of cement stone and concrete at an early stage of hardening [1]. During this period, all types of shrinkage deformations develop, they are the main reason for the formation of cracks, which then become centers of corrosion of concrete and reinforcement, limiting or completely eliminating the serviceability of concrete and reinforced concrete structures [2].*

*Due to this, the total number of pores decreases, and the density of the "cement stone – aggregate" contact also increases [3]. When prescribing the dosage of a microfiller (MF), which exhibits hydraulic activity due to the binding of free calcium hydroxide, it is necessary to be guided not only by the principle of the most complete filling of intergranular voids in the base binder, but also to maintain a sufficient alkaline potential of the cement paste [1]. In this regard, when prescribing the composition of the composite binder, it is necessary to optimize the MF dosages and not exceed the critical content of the active filler, taking into account its degree of dispersion and hydraulic activity.*

## RESULTS AND DISCUSSION

In accordance with the developed program, studies of the influence of the initial fly ash on the properties of the concrete mix and the strength of the FGCC composition 1:2 were carried out. With a reduction in cement consumption by 10, 20, 30%, the filler consumption was calculated from the condition of maintaining the cement paste volume. The research results are presented in Table. 1.

As can be seen from Table. 1, increasing the fly ash content from 37 kg/m3 to 111 kg/m$^3$ in the FGCC composition increased the fluidity of the mixture from 19.5 cm to 24.5 cm flow of a standard cone on a shaker table.

*Tab. 1*

***Composition and properties of tested concrete mixes***

| No. | Materials consump-tion, kg/m$^3$ | | | | Water/ binder ratio | *D*, cm | $R_S$, MPa | $R_{com}$, MPa | Porosity, % |
|---|---|---|---|---|---|---|---|---|---|
| | Cement | Cavi-tation | Water | Fly ash | | | | | |
| 1 | 500 | 1000 | 200 | — | 0,4 | 19,5 | 31,7 | 40,3 | 23,4 |
| 2 | 450 | 1000 | 200 | 37 | 0,41 | 23 | 27,1 | 34,3 | 23,3 |
| 3 | 400 | 1000 | 200 | 74 | 0,42 | 23,5 | 25,5 | 32,3 | 23,9 |
| 4 | 350 | 1000 | 200 | 111 | 0,43 | 24,5 | 27,7 | 29,1 | 23,7 |

Strength decreased from 40.3 to 29.1 MPa. In this case, the total porosity of the studied compositions was in the range of 23.3...23.9%. The study of the effect of a complex additive consisting of activated fly ash and microsilica on the properties of the concrete mixture and the strength of FGCC at a composite binder consumption of 650 kg/m³ showed that at an consumption of activated fly ash up to 10% and microsilica consumption up to 10% by weight of the binder using superplasticizer C-3 in the amount of 0.6% by weight of the binder, the compressive strength reaches 75 MPa (Table 2).

An increase in the mobility of the concrete mixture is also associated with the presence of vitreous spherical grains in the filler (Fig. 1).

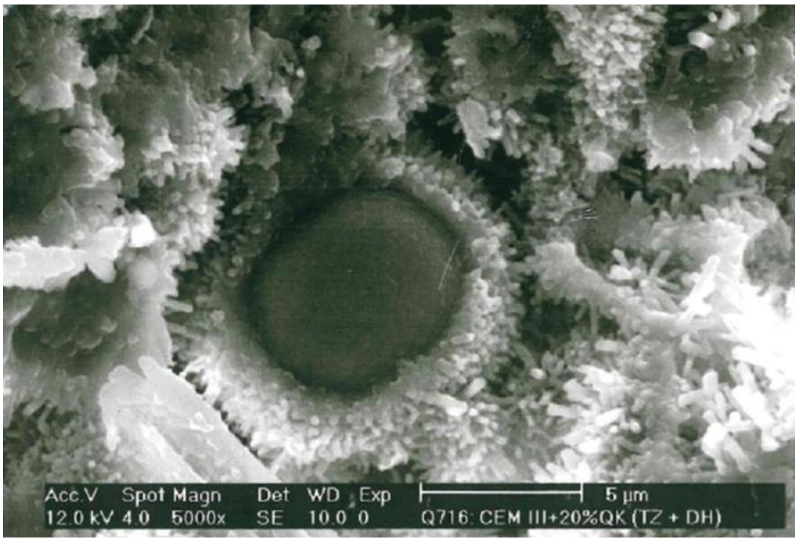


*Fig. 1. Placement of activated fly ash in the structure of cement stone*

A further increase in the consumption of MF in the composition of the composite binder is accompanied by a sharp drop in strength while maintaining a given mobility, which makes it possible to ensure the effective use of FGCC for the manufacture of structures with a concrete strength class of B30 and below.

*Tab. 2*

***Composition and properties of tested concrete mixtures with a complex additive***

| No. | Amount of activatedfly ash, % | Materials consumption, kg/m$^3$ | | | | | | $R_{com}$, MPa | $\gamma_{sv}^{св}$, kg/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|
| | | Cement | Cavi-tation | Water | Fly ash | C-3 | Microsilica | | |
| 1 | 10 | 520 | 1558 | 183 | 65 | 3,9 | 65 | 75 | 2,391 |
| 2 | 30 | 390 | 1520 | 183 | 195 | 3,9 | 65 | 42,4 | 2,353 |
| 3 | 50 | 325 | 1428 | 183 | 325 | 3,9 | 65 | 7,6 | 2,326 |

Analysis of the results of experimental studies presented in Table. 3 showed that by providing careful care for FGCC with ED during the period of the most active hardening up to 7–14 days, by creating optimal temperature and humidity conditions, it is possible to obtain concrete with high strength, crack resistance and durability.

To implement all the potential positive properties of FGCC with ED, it is necessary not only to completely bind calcium aluminates [2] during the period when the matrix structure is in an elastic-plastic state [3] and is capable of deforming without cracking [4] , but also the creation of optimal temperature and humidity conditions for hardening, excluding the development of a gradient of self-stresses over the cross section of hardening concrete.

Studies of the durability of prefabricated and monolithic reinforced concrete enclosing structures (external wall panels, uncovered reinforced concrete roof structures) made on the basis of concrete with ED, which were used for a long time in various natural and climatic conditions, showed that due to the - twisting of shrinkage deformations, self-stress losses do not exceed 55% while maintaining the design strength indicators. At the same time, the remaining level of self-stress provided the specified requirements for crack resistance, and the indicators for strength, water resistance and frost resistance were significantly higher than for ordinary concrete based on Portland cement [3].

**CONCLUSION**

It has been established that the introduction of finely dispersed MF with different hydraulic activity into the composition of the base Portland cement makes it possible to obtain high-quality FGCC of a cast consistency, corresponding in its properties to self-compacting concrete mixtures. The use of complex mineral fillers containing ED on a sulfoaluminate basis makes it possible to obtain FGCC with residual expansion, which have increased strength, crack resistance, and durability. To realize all the potential possibilities of expanding cements, it is sufficient, instead of aging in water conditions, to ensure the exclusion of moisture loss for a period of up to 14 days.

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