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Some Aspects of the Effect of Porosity on Moisture Transfer in Concrete

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Annotation: *The question of the influence of a complex additive on the process of moisture transfer in cement concrete is considered. The results of studies of the formation of the porous structure of concretes in the presence of modifying additives are presented and the mechanism of moisture transfer in high-quality concretes of a new generation is explained.*

Key words: *concrete, filler, polycarboxylate superplasticizer, water absorption, moisture transfer.*

The mechanism of moisture transfer in concrete is a poorly understood process. The process of moisture migration depends on a number of factors such as porosity, density, permeability, etc [1-4].

Without a doubt, it can be argued that the main factors contributing to the transfer of moisture in the body of concrete is the presence of pores, various defects and voids. Studies [5-7] found that moisture transfer in cement composites depends mainly on the pore size.

Domestic and foreign scientists have shown that it is possible to reduce the porosity, and subsequently the permeability of concrete, when using high-quality multicomponent concretes of a new generation with complex modifiers based on superplasticizer and mineral powder [7-12].

The analysis of the above works showed that, in general, the studies performed were aimed at solving the problems of increasing the physical and mechanical parameters of the designed concretes. In these studies, there is practically no information on the effect of mineral fillers of various nature on the formation of the pore structure and the process of concrete moisture transfer [12-14].

This article presents the results of studying the processes of moisture transfer in the pore space of concrete based on a complex additive with fillers of various nature.

In order to expand information on moisture migration in concrete, using mineral fillers of various origins and plasticizing agents, cylindrical concrete samples with a diameter and height of 150 mm were made. Data on the studied compositions of concrete are given in table. 1. The samples were immersed in water to a depth of 10 mm. The exposure time ranged from 1 hour to 60 hours. The tests were carried out on samples aged 3, 7, 28 days of hardening under normal conditions after their preliminary drying at a

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temperature of 105 °C to constant weight. The side surface of the samples was waxed to the full height to prevent moisture evaporation through the side surfaces.

Table 1

The studied compositions of the concrete mix

№	Concrete class	Cone draft, см	Cement, кг	Crushed stone, kg fr. 5-20	Sand, kg $M_{кр}$=2,7	Water, l	Fly ash, kg	Steelmaking waste, kg	Superplasticizer POLIMIX, kg
Structure №1	B15	1-2	236	1220	715	190	-	-	-
Structure №2	B15	1-2	201	1220	792	133	35	-	1.89
Structure №3	B15	1-2	201	1220	792	133	-	35	1.89

The porosity values of the cement stone were determined on a mercury porosimeter manufactured by Thermo Scientific Pascal 240 (Italy). The fabricated samples were immersed in a CD3 dilatometer to form a vacuum on the vacuumizer. After the formation of a vacuum, the dilatometer was filled with mercury and immersed in the autoclave compartment of the porosimeter to obtain porograms.

The porograms were calculated automatically using the SOLID EVO program and determined the total porosity (%).

The data of the total porosity of the studied concrete samples are shown in Fig.. 1-3.

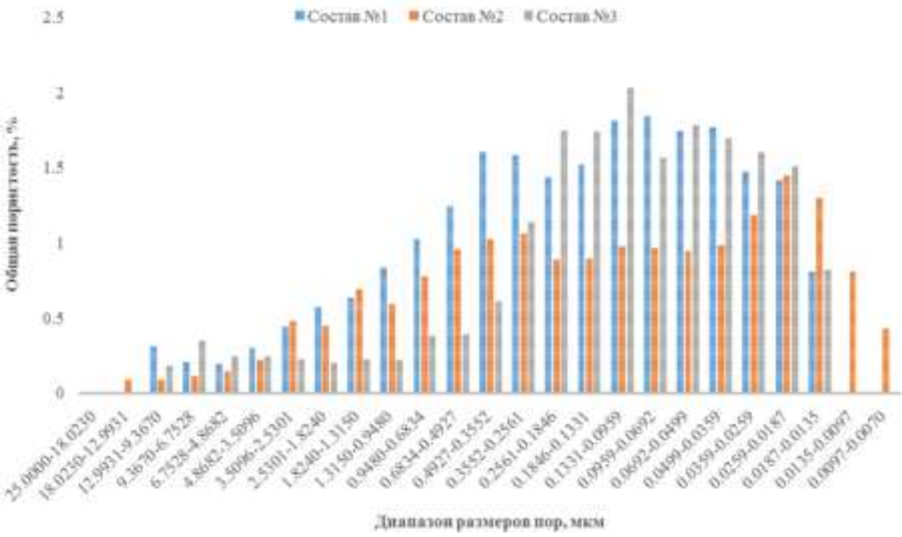

Fig. 1. Total porosity by size of the studied compositions at 3 days of age

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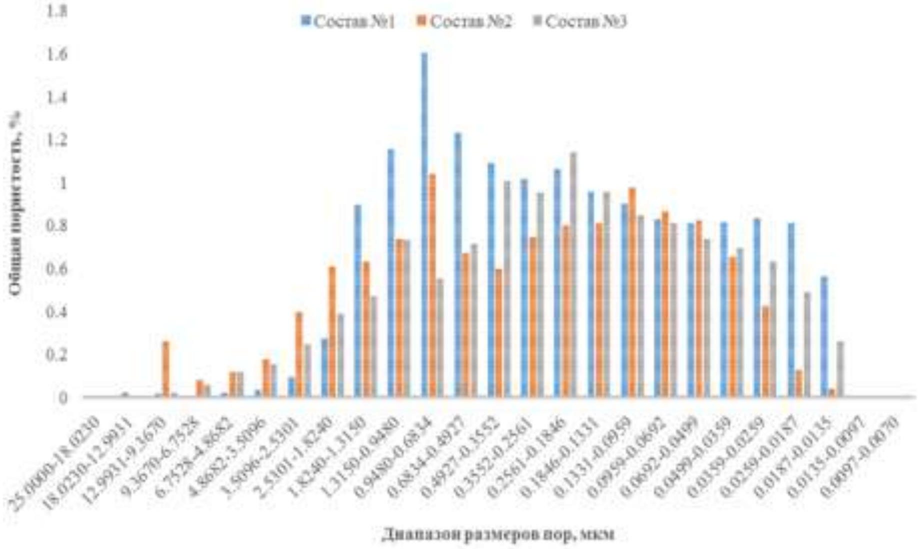

Fig. 2. Total porosity by size of the studied compositions at 14 days of age

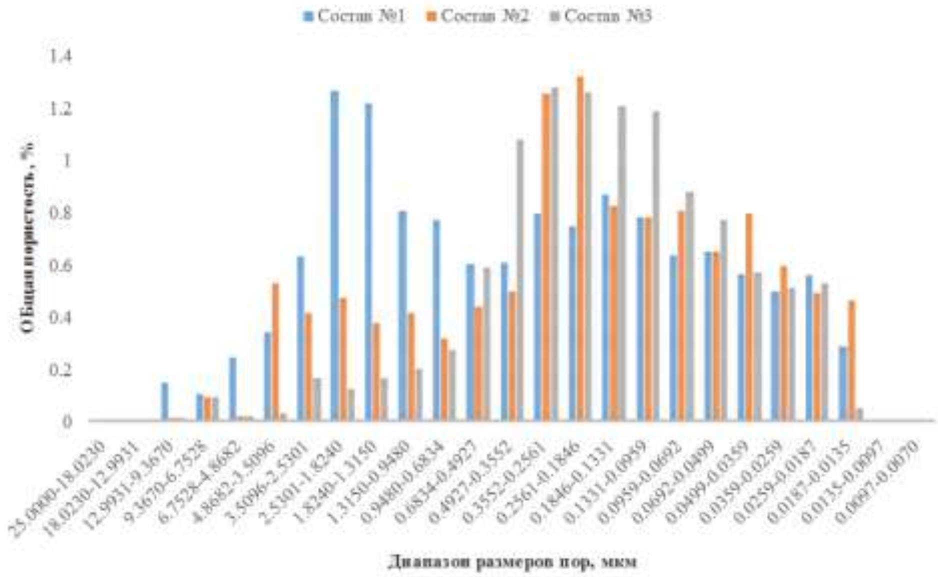

Fig. 3. Total porosity by size of the studied compositions at 28 days of age

The data obtained (Fig. 1-3) indicates that the introduction of a complex additive in compositions No. 2 and No. 3 contributes to a significant decrease in the total porosity in relation to the reference composition in all hardening periods. From fig. 2 and 3 it follows that in the complex modified composition based on fly ash, the formation of large pores having a capillary shape is observed. In the later stages of hardening, this type of pore is significantly reduced due to neoplasms. In composition No. 3, the total porosity does not change much in all periods of hardening. This is due to the fact that the additive based on steelmaking waste does not have pozzolanic activity and its active components do not enter into the reaction. Basically, in composition No. 3, a sharp increase in the number of gel pores is observed on the first day. The total porosity indicators for composition No. 2 are reduced by an average of 15.23 %, and for composition No. 3 this value is 26.41 %.

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The water absorption data of the studied concrete samples are shown in fig. 4-6.

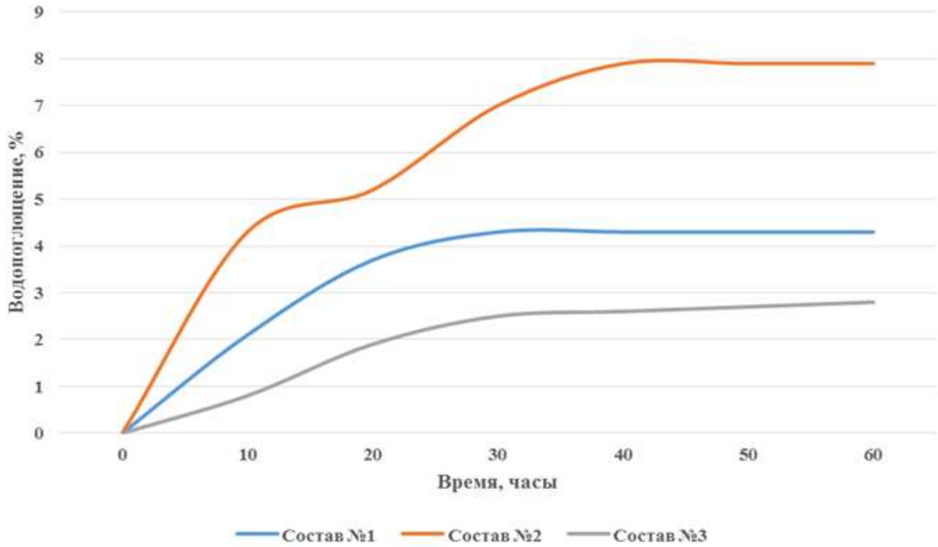

Fig. 4. Dependence of water absorption of concrete samples in the process of moisture transfer at 3 days old

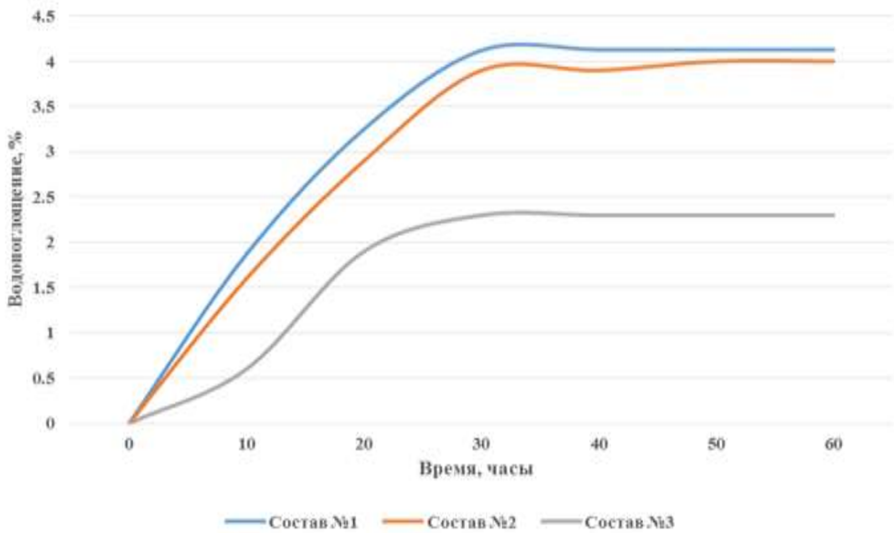

Fig. 5. Dependence of water absorption of concrete samples in the process of moisture transfer at 14 days of age

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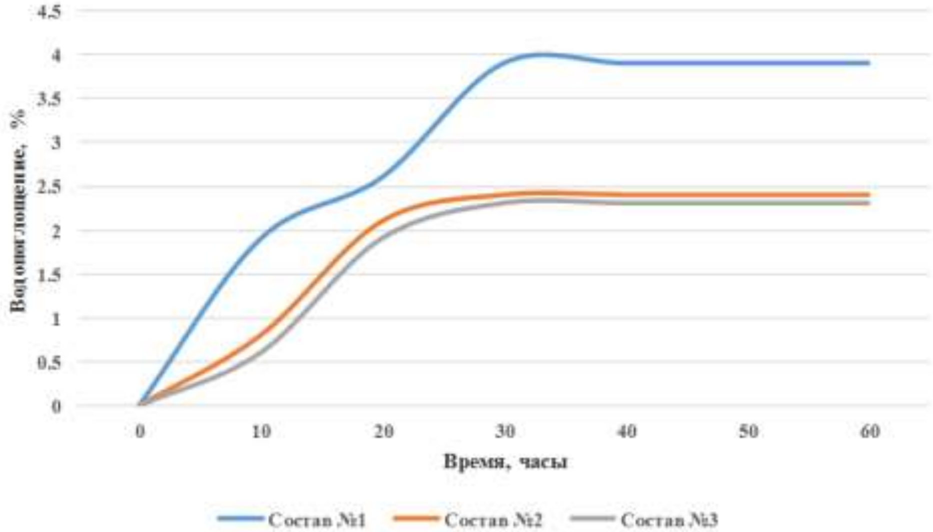

Fig. 6. Dependence of water absorption of concrete samples in the process of moisture transfer at 28 days of age

An analysis of the data obtained on the moisture transfer of the studied compositions indicates that composition No. 2 has the highest water absorption rate in the first day of hardening. This indicator is 45-46 % more than that of composition No. 1 and 63-79 % more than that of composition No. 3. In our opinion, this is due to the formation of secondary porosity due to an increase in the water demand of the system and also due to the presence of a negative charge on the particles of fly ash, the formation of conglomerates with increased porosity..

By the age of 14 days, the water absorption of composition No. 2 decreases in relation to composition No. 1 (standard) by 5-7 %. This is due, in our opinion, to the transition of free calcium hydroxide into stronger compounds, a significant degree of compaction of the structure and a decrease in the number of pores. As a result, the gap between the water absorption values of composition No. 2 and composition No. 3 is 37-72 %. At all periods of hardening, the water absorption of the complex-modified composition with the use of steel-smelting slag does not change dramatically. In our opinion, this is due to the blocking properties of the filler, which, in turn, convert capillary pores into dead ends and by the 28-day period, the porosity of compositions No. 2 and No. 3 becomes identical and decreases relative to the reference by 18-35 %. From the analysis of the data, it can be concluded that the use of mineral fillers of various nature (active or inert) can reduce the transfer of moisture in the concrete body.

The results obtained indicate a positive effect of complex modifiers on the formation of the required indicators of concrete properties, and as a result, due to the deeper flow of hydration processes in the system "cement + water + complex modifier", a porous structure is created that contributes to a significant reduction in the water absorption of the composite.

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