ABOUT THE INFLUENCE OF A ZEOLITE CONTAINING FILLER (NATROLITE) ON THE PROPERTIES OF CEMENT BINDER

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ABSTRACT

The research paper of the influence of the zeolite-containing filler of the Beltau field on the properties of the cement binder. The results of the experiment of the influence of dispersity and degree of filling on the strength of cement stone are graphically presented. The data obtained confirm the feasibility of using this type of filler in concrete.

Key words: Zeolite-containing rock, mineral additive, cement stone, strength, polycarboxylate superplasticizer.

INTRODUCTION

As you know, currently the high quality of concrete and reinforced concrete structures is ensured through the use of high-quality new generation concrete (HQNGC) [1].

HQNGC combines a wide range of concretes for various purposes: high-strength and ultra-high-strength, self-leveling, highly corrosion-resistant, dispersion-reinforced, etc. New generation concretes meet high requirements for strength, crack resistance, impact strength, wear resistance, corrosion resistance, frost resistance [1,2]. An important operational redistribution in the technology of producing high-quality concrete is directed structure formation of cement stone by means of structure modification. Among material scientists, studies are already known to improve the properties of materials with modifying additives. However, it should be noted that the use of mineral additives with certain chemical compositions is considered an effective way to obtain high-quality concrete [3-5].

The modifying effect of mineral additives is manifested in an increase in the degree of cement hydration due to the high cation-exchange activity of the filler, in the compaction of the cement stone structure and a decrease in macroporosity, in a change in the dispersion of the formed hydrates. The manifestation and ratio of surface and chemical properties in quantitative and temporal terms primarily depends on the chemical composition of the additive [6]. It is known that natural zeolites have high surface energy and chemical activity. The nature of the use of zeolites depends on their adsorption properties, features of the diffusion effect.

Zeolites are crystalline aqueous aluminosilicates of alkali or alkaline earth metals. They are characterized by a loose structure with wide channels and cavities at the level of the crystal lattice, which determines the uniqueness of their properties: molecular sieve effect, high ion-exchange, sorption and catalytic capacity. Research in the field of the use of natural zeolites in cement systems in various years was carried out by Z.A. Chistyakova, V.V. Bayrakov, O. P. Mchedlova-Petrosyan, M.M. Sychev, I.M. Makhamataliev, V.M. Choi and others [7, 8]. Knowing the dimensions of the adsorbed entrance windows of the zeolite, it is possible to select a certain diffusion form of the zeolite to control the hydration process of hardening of the cement system (Fig. 1).

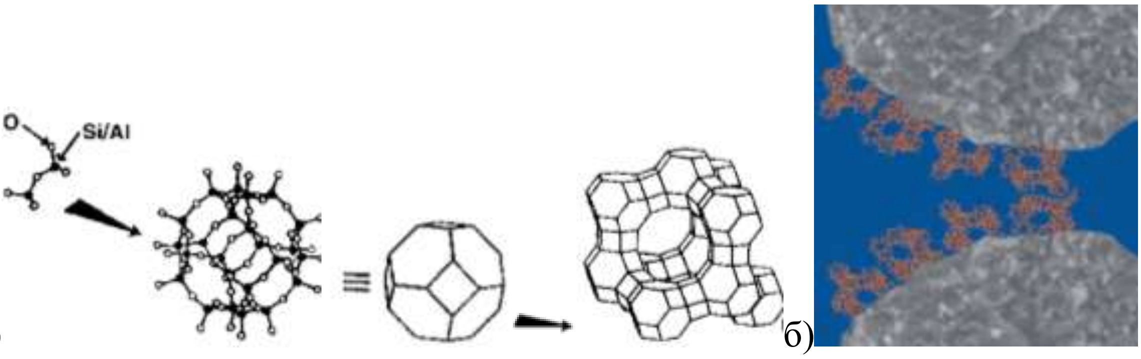

Figure 1.a) coagulation of zeolite sol, b) adsorption of zeolite sol on the surface of cement grains

However, it should be noted that there is no consensus among scientists and specialists about the mechanism of influence of zeolite-containing rocks of various types on the formation of the structure and properties of filled concrete. In this regard, in this article, experimental studies were carried out to establish the influence of the ZCR of the filler (natrolite) of the Beltau deposit and the superplasticizer on the properties of the cement binder.

CHARACTERISTICS OF MATERIALS AND RESEARCH METHODS

In experimental studies, we used M400 Portland cement of the Akhangaran cement plant. The chemical composition of Portland cement was characterized by the following oxide content: CaO-65,8%, SiO_2 -22,1%, Al_2O_3- 4,5%, Fe_2O_3- 4,2%, SO_3-0,6%, MgO-1,7%, Na_2O - 0,2%, K_2O- 0,4%, p.p.- 0,2%. The mineralogical composition of portland cement is as follows: C_3S -57,5 %, C_2S -17,8 %, C_3A -4,7 %, C_4AF -12,5 %.

As a mineral filler for concrete, a zeolite-containing rock (natrolite) of the Beltau deposit of the following chemical composition was used: CaO-1,24 %, SiO_2 – 64,96 %, Al_2O_3- 22,88 %, Fe_2O_3- 4,41 %, SO_3-0,03 %, MgO-2,07 %, Na_2O – 9,14 %, K_2O – 1,30 %, p.p.- 12 %.

The surfactant used was a polycarboxylate superplasticizer (SP) POLIMIX from ARMENT CONSTRUCTION CHEMICALS. The water-reducing effect of SP is 30%, the dosage is 0.2-1.2% of the binder mass. The normal density and setting time of the cement paste was determined using the VIKA device. To establish the optimum value of the specific surface area and the degree of filling, samples of 2x2x2 cm were made and after normal hardening at the age of 28 days, the compressive strength was determined. When preparing the cement paste, water was introduced in two steps. First, half of the mixing water was pulverized and the cement was moistened, then the rest of the water was mixed with the moistened cement. After the set hardening regime, the samples were tested on a CT-P2000 hydraulic press.

RESULTS AND DISCUSSION

As shown above, the type of chemical modifier, its dosage, as well as the chemical and mineralogical composition, dispersion and amount of mineral filler have a significant effect on the processes of structure formation of cement stone [9]. For this purpose, studies have been carried out to establish the effect of the addition of SP and zeolite-containing filler (ZCR) on the normal density and setting time of the cement paste and the compressive strength of cement stone.

The dosage of the superplasticizer (SP) was changed within 0.2 to 1.2% by weight of cement. The results of determining the normal density (ND) and the setting time of the cement paste are given in table. one.

Table data 1 show that due to the manifestation of the superplasticizing effect of SP, with an increase in dosage from 0.2 to 1.2% ND decreases by 3-8 points.

The greatest decrease in the LH of the cement paste is observed at a SP dosage of 0.8%, while a further increase does not affect the LH value. It was found that due to an increase in the forces of electrostatic repulsion of molecules, the SP has a stabilizing effect during the coagulation period of the structure formation of the binder.

Table 1. Influence of the dosage of the superplasticizer on the normal density and setting time of the cement paste

Supplement dosage, %	Normal density, %	Setting time, hour-min	
		beginning	finish
0	26	1-05	6-20
0,2	23	1-50	5-00
0,4	22	2-10	4-40
0,6	21	2-35	4-20
0,8	18	2-45	4-10
1,0	18	2-55	4-10
1,2	18	2-55	4-10

As a result of this mechanism of action, the onset of setting is lengthened from 1 hour 5 minutes to 2 hours-55 minutes. In this case, the end of the setting of the binder is reduced from 6 hours 20 minutes to 4 hours 10 minutes.

Undoubted scientific interest is the question of the influence of the specific surface area of the cement-bonded particle board filler on the formation of the strength of the cement stone. To study this issue, samples were prepared from cement paste of normal density, the value of which was taken for the original cements, equal to 27% of the binder weight. In order to establish rational values of the specific surface area of the filler and the degree of filling of the cement binder, studies are given with various values of the specific surface area of the cement bonded particle board filler: 1010, 2060, 3010, 4220, 5080 cm^2 / g and the degree of filling 10%, 20%, 30%, 40%. 50%.

The strength characteristics of a cement binder with different degrees of filling were studied on standard cubes measuring 2x2x2 cm, the degree of filling was taken as 30% of the cement mass. After statistical processing of the results of the experimental data, the following graphical dependencies were obtained (Fig. 2, 3).

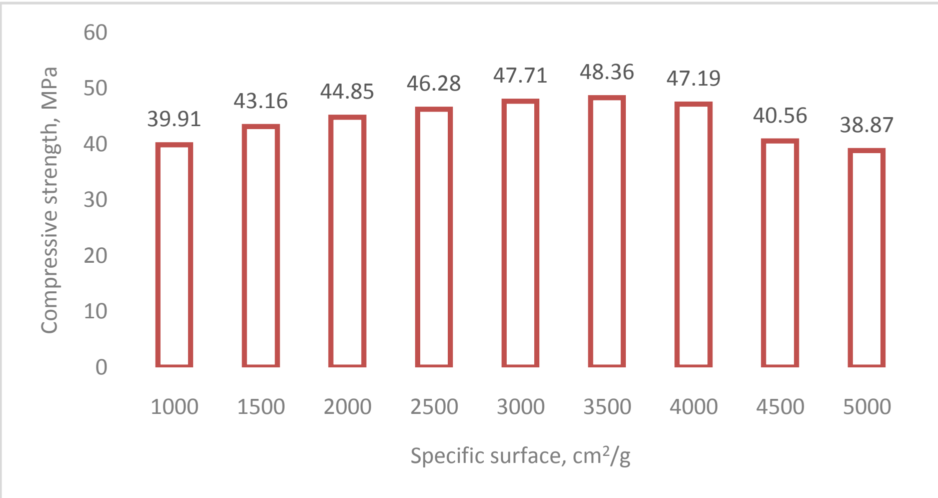

Figure 2. Influence of the specific surface area of the ZCR filler on the strength of the cement stone (with a degree of filling of 30%)

Fig. 2 that the change in the strength of the cement stone depending on the dispersion of the filler has an extreme character at S_{SG}=3300÷3500 sm^2/g.

This is explained by the structuring effect of the filler, and its strengthening effect is probably associated with the interaction of its oxides with the calcium-containing phases of the cement. This is quite natural and is in good agreement with the conclusions given in [10-13], which indicates that when the surface activity of the filler F_N is greater than or equal to the surface activity of the binder F_B ($F_N \geq F_B$), the optimal size of the filler is commensurate with the grain size of the binder. In our case, the rational specific surface area of the cement-bonded particle board S_{SG} = 3300 ÷ 3500 cm^2 / g is comparable with the similar indicator of the binder S_{SG} = 3000 ÷ 3500 cm^2 / g. As can be seen from (Fig. 3), filling the cement binder (30%) of ZCR with a filler with dispersion S_{SG} = 3500 cm^2 / g improves the strength characteristics of the cement stone. This indicates that the zone of the rational degree of filling is within these limits.

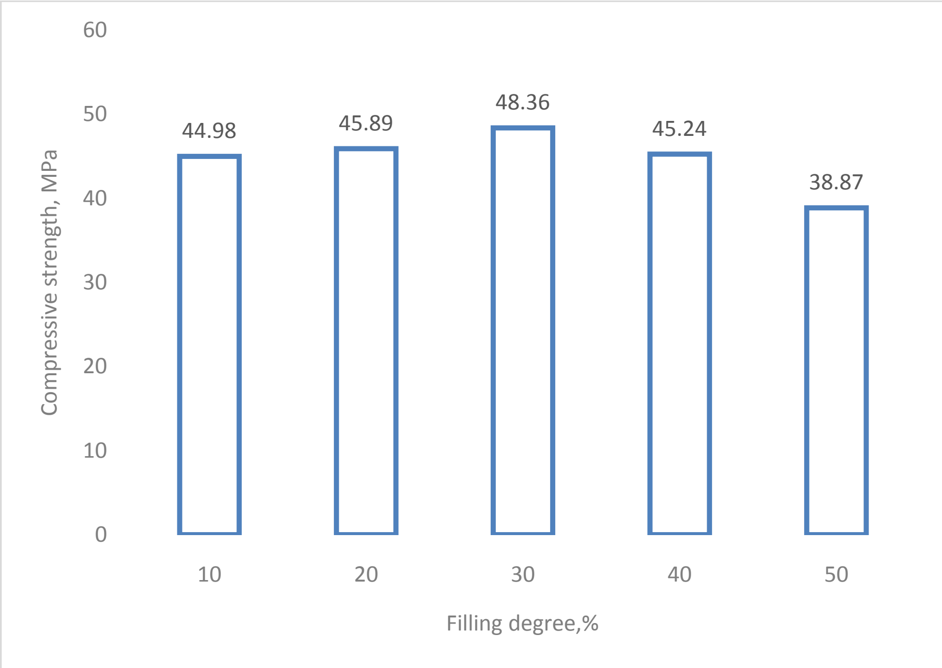

Figure 3. Influence of the degree of filling of the cement binder on the strength of the cement stone (at S_{SG} ZCR filler 3500 cm^2/g)

The dependence of the strength of the cement stone on the degree of filling is also extreme, with a max at 30%. A further increase in the degree of filling leads to a natural decrease in the strength of the cement stone, due to a decrease in the proportion of the original cement. The dependence of the compressive strength on the degree of filling and specific surface area is shown in Fig. 4. Thus, rational values of S_{SG} of ZCR filler should be considered ~ 3500 cm^2 / g, and the degree of filling - 30%. With this in mind, in the next series of experiments, we determined NG and the setting time of the binder with the addition of 0.8% SP and filler with S_{SG} ~ 3500 cm^2 / g. The degree of filling was taken as 30% by weight of the binder. The results of determining NG and the setting time of the filled binder are given in table. 2.

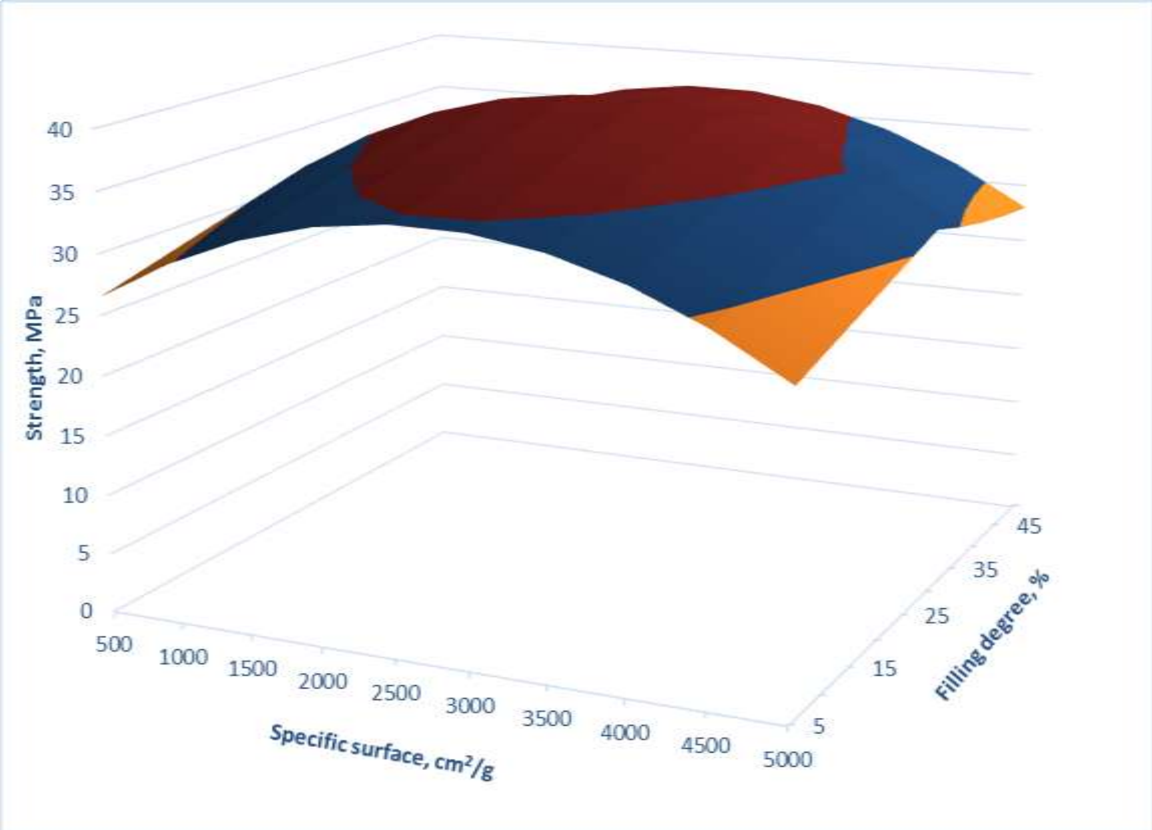

Figure 4. Dependence of the strength of the cement stone on the degree of filling and specific surface

Table 2. Influence of the cement paste filler with S_{SG} ~ 3500 cm²/ g and at the degree of filling 30% on the normal density and setting time of the cement paste with the additive

Supplement dosage, %	Normal density, %	Setting time, hour-min	
		beginning	finish
0	26	2-55	4-35
0,2	23	2-50	4-30
0,4	22	2-35	4-20
0,6	21	2-25	4-10
0,8	18	2-20	4-00
1,0	18	2-20	4-00
1,2	18	2-20	4-00

Analysis of the above data shows that with a content of 30% ZCR filler at a dosage of SP 0.8% NG decreases to 18%. This indirectly indicates that the hydrophilicity and adsorption activity of the ZCR filler is less than that of cement, which has a positive effect on the water demand of the filled binder. Comparison of the data on the setting time of filled and unfilled cement with the addition of SP shows that the introduction of the ZCR filler, due to the structuring action, insignificantly reduces the setting time of the binder, which should not have a negative effect on the preservation of the fluidity of the concrete mixture. This is confirmed by the results of studies of the rheological properties of cement mixtures. The complex use of additives SP and ZCR filler with a hardening effect makes it possible to obtain a cement binder with high strength properties. A rational dosage of SP and ZCR filler provides a high-strength cement stone with 86 MPa, as evidenced by the data shown in Fig. 5.

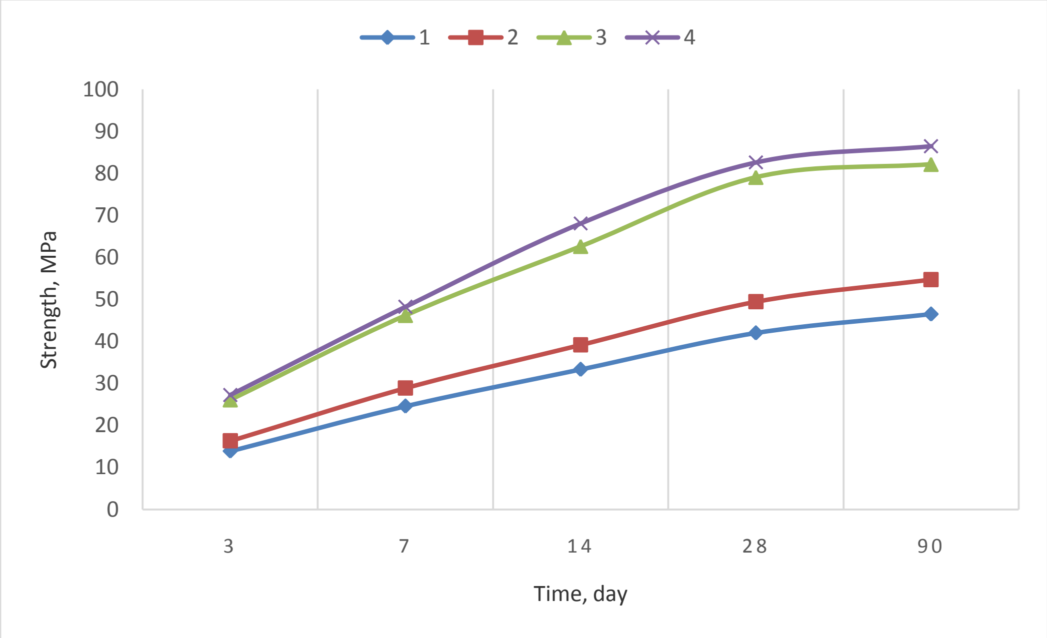

Figure 5. Change in the strength of the cement stone over time. 1-cement; 2-cement + CBPB (30%); 3-cement + joint venture (0.8%); 4-cement + SP (0.8%) + CSP (30%)

At the same time, the initial strength of the binder and the composite filled with dispersed filler is still 15% higher than that of unfilled one. This is probably a consequence of the interaction of the filler with the calcium-containing crystalline hydrates of the cement stone. As seen from Fig. 4 the maximum strength of the cement stone is observed with the complex use of modifiers and in 28 days old is 86 MPa. At the same time, the same indicators of the strength of the original cement stone are 48 MPa.

CONCLUSION

From the data obtained, the following conclusions can be drawn:

- the introduction of a polycarboxylate superplasticizer reduces NG by 3-8 points. The most sensitive NG of the cement paste is reduced at a dosage of SP 0.8%. Further increase in dosage does not affect NG;

- the optimal dispersion of the filler is in the range S_{SG} = 3300 ÷ 3500 cm^2/g, where the extremum of the strength of the cement stone is observed;

- the dependence of the strength of the cement stone on the degree of filling also has an extreme character with max at 30% filler content.

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