SOME FEATURES OF RHEOLOGICAL PROPERTIES OF CEMENT PASTS WITH ZEOLITE-CONTAINING FILLERS

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ABSTRACT

The results of the effect of a complex modifier based on a polycarboxylate superplasticizer and a zeolite-containing rock on the rheological properties of cement systems are presented. The results of the structural viscosity and ultimate stress from the consumption of the superplasticizer are presented.

Key words: structural viscosity, ultimate shear stress, cement system, zeolite-containing rock, polycarboxylate plasticizer.

INTRODUCTION

The introduction of finely ground mineral additives into the composition of concrete allows to reduce the consumption of cement without deteriorating its quality, to control the kinetics of structure formation and the degree of hydration of cement minerals. As a result of the chemical combination of additives (mainly silica) with hydration products, new formations are created, which significantly compact and strengthen the structure of the cement stone [1].

In addition to the positive effect, mineral additives in the compositions of composite cements can have a negative effect on the mobility of the concrete mixture [2].

According to the authors of [3], a decrease in mobility occurs due to the use of mineral additives with negative electrokinetic potential, which cause flocculation of microcrystalline components. The authors argue that, to prevent flocculation, it is necessary to use dispersed mineral particles with a positive electrokinetic potential.

Some microfillers, for example, fly ash, negatively affect the water demand and flowability of concrete mixes. This may be due to the appearance of a negative electrokinetic potential or the formation of cracks on the surface of ash particles that absorb a significant amount of water, which subsequently leads to an increase in water demand.

The authors of [4] argue that the mineral additives present in the composition of some clay rocks (sungulites, chlorites, oungulites) have a plasticizing effect.

Based on the foregoing, the purpose of this study is to study the effect of zeolite-containing (ZCR) micro-filler (natrolite) and superplasticizer (SP) on the rheological properties of cement pastes.

APPLIED MATERIALS AND RESEARCH METHODS

Investigations of the rheological parameters of filled cement systems were carried out with different content of superplasticizer (SP), and as a microfiller, we used ZCR (natrolite) from the Beltau field. The SP was a POLIMIX polycarboxylate superplasticizer from ARMENT CONSTRUCTION CHEMICALS.

The preparation of the binder was carried out separately - first, the filler made of ZCR ground to a specific surface of 3400 cm^2/g and cement were mixed with a part of the mixing water, and then with the rest of the water and the additive. The filler consumption was taken constant and equal to 30% of the cement mass, and the SP dosage was changed within 0.2-1.2% of the cement mass with a step of 0.2.

The ultimate shear stress of the cement system was estimated according to the method developed [5] and was calculated by the formula:

$$\tau_0 = \frac{hd^2\rho g}{kD^2}, \qquad (1)$$

where τ_0 is the limiting shear stress of the suspension, Pa; h and d - respectively, the height and diameter of the viscometer, m; ρ is the density of the suspension, kg/m^3; g-free fall acceleration 9.81 m/s^2; k is the coefficient taking into account the redistribution of stresses in viscoplastic bodies, equal to 2; D is the diameter of the spreading of the suspension, m.

When determining the structural viscosity of cement pastes, the Stokes method was used [6]. The method is based on the rise or fall of spherical bodies and is calculated using the following formula:

$$\eta = k(\rho_1 - \rho_2)T, \quad (2)$$

where η - structural viscosity, (Pa*s); k is the device constant equal to 0.000223, ρ_1 and ρ_2 are the densities of the system under study and the ball, kg/m^3; T is the time for the balloon to emerge, sec.

RESULTS AND DISCUSSION

Before setting, the cement dough has mainly a coagulation structure. The destruction of such structures occurs with mechanical action on the system (vibration, shaking, stirring, etc.). In this case, the structural viscosity decreases and the suspension acquires the ability to flow. After the termination of mechanical actions, the structural bonds in the system are restored again, the viscosity of the suspension increases, and the fluid state disappears. The most important characteristics of this state of the cement paste are the structural viscosity (η) and the ultimate shear stress (τ_0), the changes of which can be determined with high accuracy by the methods [5, 6].

At the first stage, the structural viscosity of filled and unfilled cement pastes was compared. Analysis of experimental data showed that the use of SP significantly reduces the structural viscosity of filled and unfilled cement pastes (Fig. 1). The decrease in viscosity is associated with a decrease in friction between the binder and filler particles.

Fig. 1, the following conclusions can be drawn: at low dosages of SP up to 0.5%, the viscosity of the filled paste is 14% higher than the control, with an increase in the dosage of SP from 0.5% to 1.2%, the η index of the filled cement paste decreases to 3,26 Pa*s, which in turn is 22% lower in comparison with the control. In our opinion, this is due to the fact that an increase in the content of the SP additive intensifies the plasticizing effect. The mineral filler introduced into the composition helps to increase the plasticity of the paste and allows it to reduce the SP dosage by 22% while maintaining the required mobility.

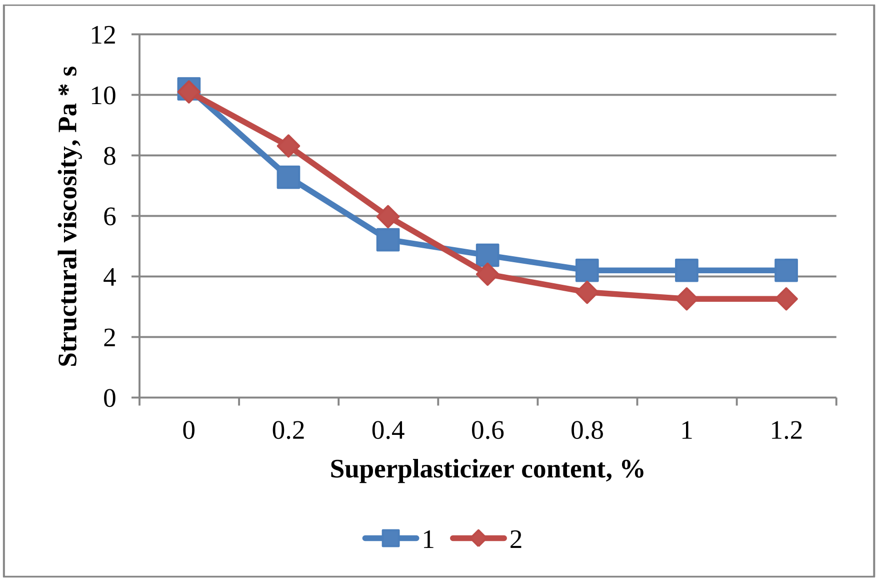

Figure: 1. Structural viscosity of unfilled (1) and cement pastes filled with ZCR (2)

At the second stage, the ultimate shear stress was determined using a modified V.I. Kalashnikov with an equal spread of a mini-cylinder 80 mm. For this, the W/C was reduced with the addition of SP to obtain the same solution mobility. At the same time, in conditions of equal mobility, the studied cement pastes are characterized by different values of τ_0.

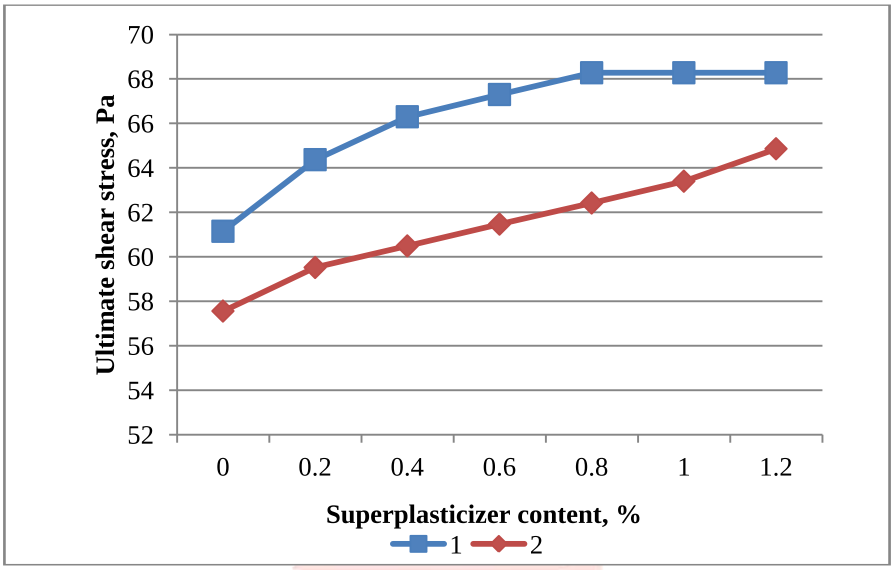

Figure: 2. Ultimate shear stress of unfilled (1) and filled (2) cement pastes

Analysis of Fig. 2 indicates that, with a decrease in water consumption in unfilled pastes, the ultimate shear stress increases by 5-8% than filled ones.

The limiting stress of unfilled paste increases with an increase in SP to 0.8% and reaches its extreme at 68.28 Pa. A further increase in the dosage does not affect the increase in the value of τ0. For the second composition, the extreme is observed at a dosage of 1.2% and is equal to 65.2 Pa.

CONCLUSION

From the results obtained, it can be stated that the use of ZCR contributes to a significant decrease in internal friction, leading to a decrease in the τ_0 index. As a result of this effect, it becomes possible to reduce the SP consumption by 22% while maintaining the required mobility and, among other things, to ensure high vibration compaction of the mixture and significantly increase the density of the formed concrete.

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