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Study of the Effect of Chemical Additives on Cement Stone and Determination of Its Optimal Composition

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Abstract: The article presents the results of experimental studies of the effect of the amount of chemical additives on the physical and mechanical properties of fine-grained concrete.

Keywords: fine-grained concrete, chemical additive, cement, water, superplasticizer.

INTRODUCTION

Chemical additives can be used to improve the properties and quality of concrete mixtures and concrete. These additives serve to enhance the primary quality indicators of concrete mixtures and concrete. They increase the workability of the concrete mixture, save cement consumption, and improve the physical and mechanical properties of concrete. Currently, plasticizers, superplasticizers, and hyperplasticizers are widely used as chemical additives.

In this research, the interaction of fine-grained concrete with chemical additives was studied. The strength indicators of concrete were examined based on the selected composition.

MATERIALS AND METHODS

The normal consistency and setting time of the selected cement paste were determined using a Vicat apparatus according to the standard method outlined in GOST 310.3-81, "Normal Consistency, Uniformity of Volume Changes, and Setting Times of Cement." The strength of cement was determined using GOST 30744-2001. The compressive and flexural strength of the

sand concrete samples was determined in accordance with GOST 310.4-81. The mobility and average density of the concrete mixture were determined based on GOST 5802-86.

RESULTS AND DISCUSSION

Cement

One of the main components in concrete preparation is binding materials. As a binding material, Portland cement was used. Portland cement is a hydraulic binder obtained by finely grinding clinker and gypsum stone (3-5%) together. It sets well in water and air and retains its strength over time.

For the experiments, Portland cement of grade M400 D0, manufactured by JSC "Kizilkumcement," was used. The quality of the cement was determined in accordance with GOST 30744-2001.

The chemical composition of Portland cement

Table 1.

№	Raw material name	Mass fraction of oxides, %								
		SiO_2	Fe_2O_3	Al_2O_3	R_2O	CaO	MgO	SO_3	k.m.k	Total
1	PC 400 D0	21,84	3,75	4,78	1,47	64,79	2,59	0,33	0,30	99,82

Superplasticizer

Chemical additives are currently the most active and widely used materials, providing convenience and efficiency in managing the properties and technology of concrete. Plasticizers, superplasticizers, and hyperplasticizers are extensively used as chemical additives.

In this study, the superplasticizer "Megaplast JK-02" was used, which has the following properties:

- Increases the plasticity of the mixture without changing water consumption.
- Enhances the strength of concrete by up to 60% and helps reduce cement consumption by up to 30%.
- Allows high-grade concrete to be produced from low-grade cement.
- Reduces the water permeability of concrete, among other benefits.

Water

To prepare the concrete mixture, drinking water or natural water without harmful impurities that could hinder the proper setting and structural formation of the concrete is used. The water used must have a pH ≥ 4 and a sulfate ion content of SO_4 ≤ 2700 mg/l. Additionally, it must not contain harmful impurities such as mineral and organic acids, oils, sugars, etc.

In this study, control concrete samples were initially prepared by adding "Megaplast JK-02" superplasticizer in amounts of 0.5%, 1%, and 1.5% relative to the cement mass. The flexural and compressive strengths of these samples were determined. To further refine the optimal dosage of the "Megaplast JK-02" superplasticizer, additional samples were prepared with 0.75%, 1%, and 1.25% superplasticizer content. Their flexural and compressive strengths were also evaluated.

Analyzing the obtained results to identify changes in the strength of fine-grained concrete with superplasticizer compared to control concrete is of significant importance. Taking this into account, the strength of concrete samples based on the control composition was determined in parallel under identical conditions during the experiments. The results are presented in the following tables and graphs.

Table 2.

Strength of Samples, MPa			
№	Compositions	Under Heat Treatment	
		$R_{эг}$	R_c
1	Control Composition	7,4	31,1
2	SP-0.5 Composition	8,1	33,5
3	SP-0.75 Composition	8,2	34,2
4	SP-1 Composition	8,4	38,5
5	SP-1.25 Composition	7,7	33,8
6	SP-1.5 Composition	7,8	34,6

Note: SP – Superplasticizer.

Figure 1.

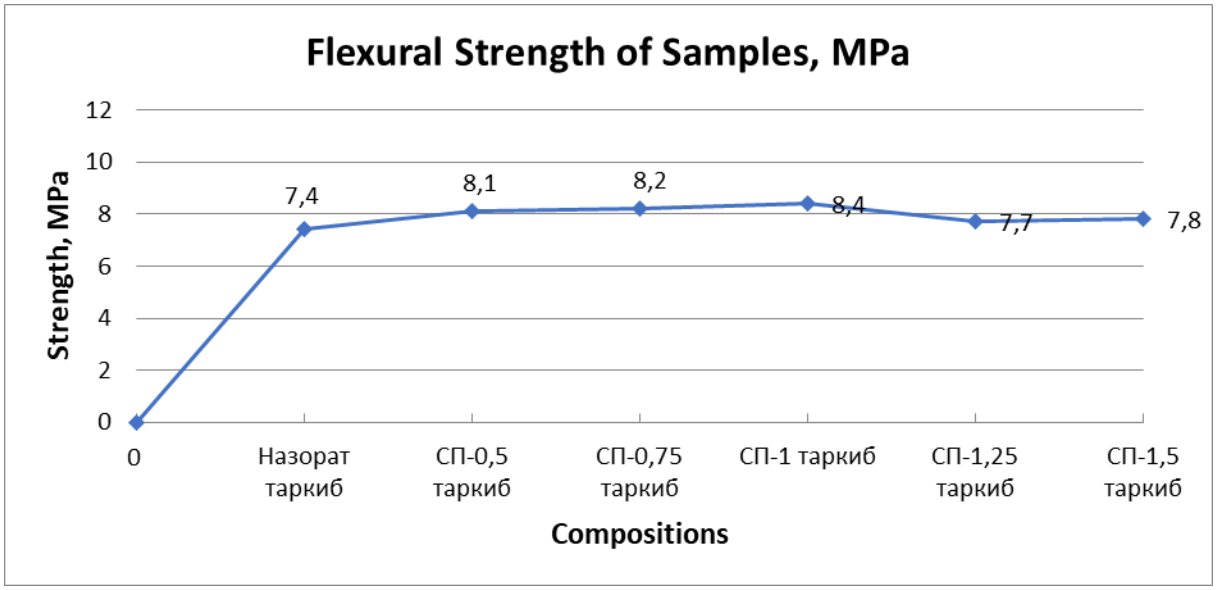
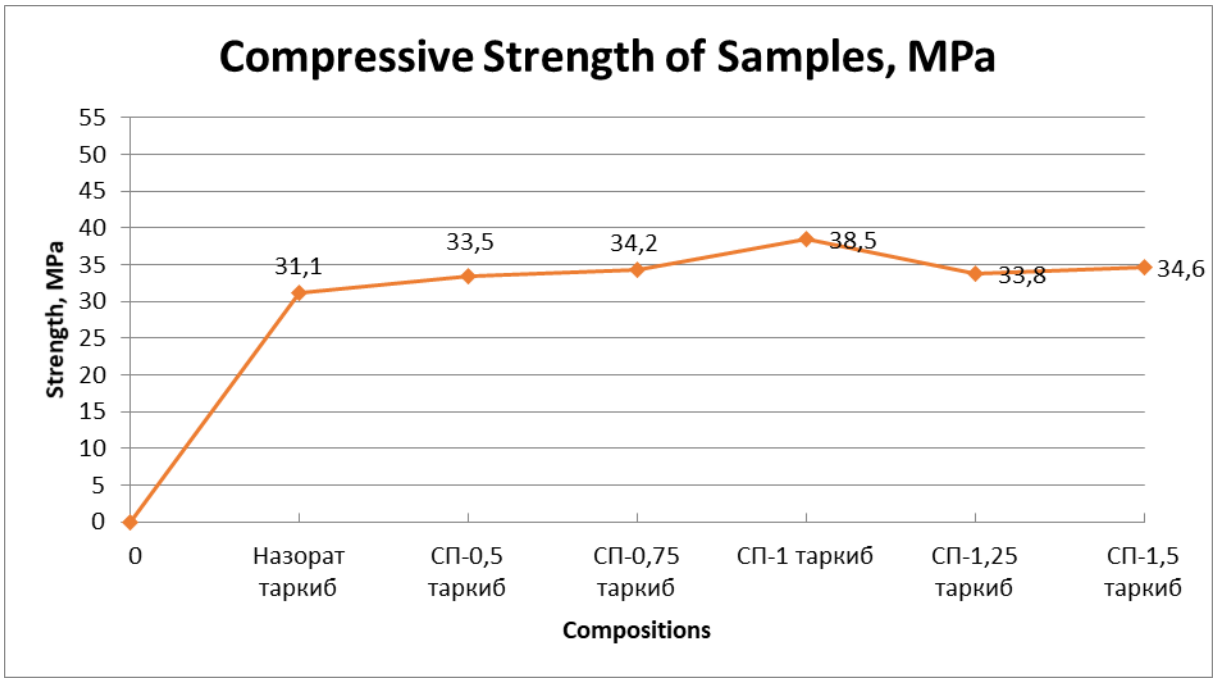


Figure 2.



CONCLUSION

The experimental research has led to the following conclusions:

1. Compared to the control composition, adding 0.5% superplasticizer increased the flexural strength by 9.4% and the compressive strength by 7.7%.
2. Adding 0.75% superplasticizer increased the flexural strength by 10.8% and the compressive strength by 9.9% compared to the control composition.
3. Adding 1.0% superplasticizer increased the flexural strength by 13.5% and the compressive strength by 23.8% compared to the control composition.
4. Adding 1.25% superplasticizer increased the flexural strength by 4.05% and the compressive strength by 8.6% compared to the control composition.
5. Adding 1.5% superplasticizer increased the flexural strength by 5.4% and the compressive strength by 11.2% compared to the control composition.

The highest flexural and compressive strengths were achieved when 1% of the "Megaplast JK-02" superplasticizer was added to the fine-grained concrete composition.

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