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THE INFLUENCE OF MATERIALS OF COMPLEX-ACTIVE MINERAL AND CHEMICAL ADDITIVES ON THE PROPERTIES OF BINDERS

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ABSTRACT

The article presents the results of research work on the development of properties of binders with complex-mineral and at the same time chemical additives and the optimal compositions are determined.

At present, research aimed at using local waste management in the form of fine mineral additives, similar in material composition to the products of cement hydration, allowing directionally regulate the properties of the binder, achieve increased properties (strength, frost resistance), to form a dense structure of a mortar mixture. Reducing the consumption of the binder in mortar and concrete mixtures due to the introduction of modifying additives is also an urgent area of research. The paper presents the results related to obtaining a complex modifying additives consisting of waste of copper-smelting production and fly ash, studied its effect on the properties of cement systems. {1}

Today, along with water, filler and binder, additives have become an indispensable component of the concrete mix. Among the many types of chemical additives, plasticizers occupy a separate place, especially the most effective of them - super plasticizers.{1} With regard to local construction practice, it should be noted that the use of super plasticizer in monolithic building technology is very low in the country. This can be explained by the fact that, firstly, in Uzbekistan, few chemical additives are produced for target concrete, including super plasticizers, and secondly, it is also a very urgent issue to conduct comparative studies of commercially available super plasticizers and develop recommendations for their practical use.

***KEY WORDS: Complex additives, industrial waste, secondary materials, fly ash, copper-smelting industry waste, chemical additives, strength, durability*.**

INTRODUCTION

Research on reducing the consumption of binder without changing the physical and mechanical characteristics of the final product by the introduction of various modifying additives.

To ensure the activity of the structure of concrete and concrete mixture, together with chemical additives, it is also advisable to add powders of various mineral rocks related to mineral additives, materials obtained in natural or man-made conditions: ash from thermal power plants, metallurgical slags and additives from various rocks.

One of the most important properties of ash as an active mineral additive in concrete is its hydraulic activity. Traditionally, it is determined by the ability of ash to absorb lime from a lime solution and to exhibit astringent properties in combination with hydrated lime. The microcalorimetric method is a new method for determining the activity of ash: the activity of ash is determined by the value of the heat of its wetting in polar and non-polar liquids. This takes into account the coefficient of hydrophilicity and other parameters. {2}

The selection of the composition of concrete with the addition of ash consists in determining such a ratio of components at which the characteristics of the concrete mixture and concrete would be achieved with a minimum consumption of cement. In the concrete mixture, ash plays the role of not only an active mineral additive that increases the amount of binder, but also the function of a microfiller, which improves the granulometry of sand and actively affects the processes of structure formation of concrete. {2}

Given the semi-functional nature of the entire additive, its introduction instead of a part of cement or sand does not make it possible to solve the problem of optimizing the composition.

Reducing the consumption of cement when adding ash is advisable first of all in the case of excessive activity of cement, that is, when the cement grade is higher than the recommended one. When using TPP ash, it is allowed to reduce the minimum typical cement consumption for unreinforced concrete products to 150 kg / m^3, and for reinforced concrete products to 180 kg / m^3. In this case, the total consumption of cement and ash must be at least 200 and 220 kg / m^3, respectively. The amount of ash should be determined in proportion to the required reduction of the Excessive activity of the cement.{3}

Adding ash in an optimal amount does not increase the water consumption of concrete mixes, which is explained by the melting of particles and their relatively regular shape. With a high dispersion of ash and an insignificant content of unburned coal in it, the workability of the mixture increases. The plasticizing effect of ash increases if there is a fine aggregate in the concrete mixture with an insufficient amount of fine fractions.

The introduction of fly ash from the combustion of lignite and bituminous coals into sandy concrete avoids excessive consumption of cement.

To achieve high strength of ash-containing concrete, the chemical and mineralogical composition of clinker is of certain importance. At an early age, the growth of concrete strength is facilitated by the increased content of alkalis in the clinker, which accelerate the chemical interaction of ash and cement; in the later, for the manifestation of the pozzolanic reaction of ash, cements with a high alite content are preferable, since during hydrolysis they form $Ca(OH)_2$.{3}

Like other hydraulic additives, ash reduces the frost resistance and heat resistance of concrete. The possibility of using ash in concretes with frost resistance F50 and higher is established by special studies. The decrease in the frost resistance of concrete can be compensated by the introduction of air-entraining additives.

LITERATURE REVIEW

The degree of elaboration of the topic. Significant contributions to the study of the composition, structure and properties of QPC with mineral additives were made by: Druzhinin S.I., Kind V.A., Yung V.N., Zhuravlev V.F., Bozhenov P.I., Budnikov P.P. , Glukhovsky V.D., Butt N.M., Volzhensky A.V., Komokhov P.G., Mchedlov-Petrosyan O.P., Massatsatsa F., Kokubu M., Yamada D., Ramachandran V.S. , Kalashnikov V.I .; and continue to contribute: Entin Z.B., Dvorkin L.I., Rakhimov R.Z., Khozin V.G., Ivaschenko Yu.G., Senators P.P., Palomo A., K. De Weerd, Morsy MS, Antoni V., Rossen J., Martirena F., Fernández-Jiménez A., Wang SD, Ludwig H.-M., Skibsted J. et al.

A number of scientific studies were also carried out by the scientific experts on the development of the compositions of complex-mineral additives, the improvement of the structure and properties of the cement paste. In their scientific research Kasimov E.U., Gaziev U.A., Samigov N.A., Akramov Kh.A., Mirakhmedov

M.M., Makhamadaliev I.M., Tulaganov A.A., Turapov M.T. ., Kamilov Kh.Kh., Shakirov T.T. and others in different years have achieved certain successes and important scientific results in this direction.

Mineral additive (MD) is a dispersed inorganic material introduced into a concrete or mortar mixture in order to regulate their technological and construction-technical properties or impart new properties to them. Mineral additives for cements

It should be noted that the term mineral additive has a broader meaning. There are mineral additives for cements. The corresponding definition is given in GOST 30515-2013 Cements. General specifications: Mineral additive is a material introduced into cement instead of a part of clinker in order to achieve certain quality indicators and (or) save fuel and energy resources

MATERIALS AND METHODS

During the research, the following materials were used:

a)binder:

Portland cement is a hydraulic binder obtained by joint grinding of cement clinker, gypsum and additives, which is dominated by calcium silicates (70-80%). This type of cement is the most widely used in all countries.

Portland cement is produced by fine grinding of clinker and gypsum. Clinker is a product of uniform firing before sintering of a homogeneous raw mixture consisting of limestone and clay of a certain composition, which ensures the predominance of calcium silicates (3CaO · SiO2 and 2CaO · SiO2 70-80%).

b) mineral additives

Fly ash. Provides in the manufacture of concrete mixes and concrete the availability and strength of concrete without deterioration of its physical, chemical and mechanical properties, along with saving the amount of binder, rational use of heat energy when used together with Portland cement, increasing the efficiency of using secondary resources, reclamation and disposal of land contaminated with industrial waste. {4}

Fly ash is a dusty material that is captured from the flue gases of TPPs using cyclones and electrostatic precipitators. The ash particle size ranges from 3–5 to 100–150 microns. The number of large particles does not exceed 10-15%. Average density of ash is 2–2.5 g / cm³, bulk density is 0.5–0.8 g / cm³. One of the most important properties of ash as an active mineral additive in concrete is its hydraulic activity. Traditionally, it is determined by the ability of ash to absorb lime from a lime solution. Improves water permeability; reduces the water-cement ratio and increases the durability of concrete; does not contain chlorine and other components that can cause corrosion when used in reinforced concrete. Suitable for use in reinforced concrete. {4}

Table-1
Chemical composition of fly ash

Name	Number of oxides, mass% by mass							
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	CO_3	$Na_2O + K_2O$	Total
Fly-ash	35,80	18,45	15,30	18,30	4,15	3,80	3,7	100,0

Waste from the copper smelting industry. In the manufacture of concrete mixes and concrete, they ensure the availability and strength of concrete without deteriorating its physical, chemical and mechanical properties, along with saving the amount of binder, rational use of heat energy when used together with Portland cement, increasing the efficiency of using secondary resources, reclamation and disposal of land contaminated with industrial waste.

The state of the waste, fired solid, slag, is characterized by a large amount of iron in the composition. After the metal is separated from the composition of this waste, it can also be used as sand or crushed stone. The slag of copper smelting is dark in color, water demand does not exceed 0.6%, the melting point is 990–1175 ° C. In terms of chemical composition, it is acidic and basic. Bulk density - 1.8 t / m³. Fraction from 2-5 to 0.25-0.5 mm. For example, granulated slags from the copper processing industry served as raw materials for binding materials for the manufacture of concrete of various grades, hardened in autoclaves. {4}

Table -2
Chemical composition of copper-smelting waste

Name	Number of oxides, mass% by mass							
Copper-smelting waste	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	CO_3	$Na_2O + K_2O$	Total
	35,80	18,45	15,30	18,30	4,15	3,80	3,7	100,0

c) chemical additives

Superplasticizer "Beton Strong-17" is considered complex, thanks to this additive, the plasticity of the concrete mixture increases, its setting time is accelerated, and the concrete is given resistance to freezing. Superplasticizer "Beton Strong-17" is a complex additive designed for cold climates, which accelerates the hardening of the concrete mixture, gives concrete antifreeze properties and increases its plasticity.

Complex plasticized admixture in concrete and building mixtures “Beton Strong 17” with frost resistance effect consists of a mixture of sodium polynaphthalene methylene sulfonate and sodium formate.

Increases the mobility of the concrete mixture from P1 to P5, mortar - from PK1 to PK4 (strength does not decrease at all times of hardening). {5}

When mixed with water, the superplasticizer reduces the water requirement of the mixture to 20–25%.

Prevents freezing of concrete and mortar mixtures before the start of active heat treatment during the construction of concrete and reinforced concrete structures. It is effective for ensuring the transportation of concrete mixture at a temperature not lower than minus 25 ° C with the condition of subsequent heat treatment of the erected structure. It is used as an anti-frost additive for warm floors at ambient temperatures up to minus 25 ° C in accordance with GOST 24211-08. {6}

Provides the ability to reduce the heat treatment of concrete in comparison with multicomponent antifreeze additives.

RESULT AND DISCUSSION

Table-3
Influence of fly ash on the properties of Portland cement

№	Portland cement amount (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
						Bend, MPa	Compression MPa
1	500	1500	200	0,4	0	10,81	31,89
2	450	1500	200	0,4	10	10,8	31,5
3	400	1500	200	0,4	20	10,0	30,6
4	350	1500	200	0,4	30	9,1	27

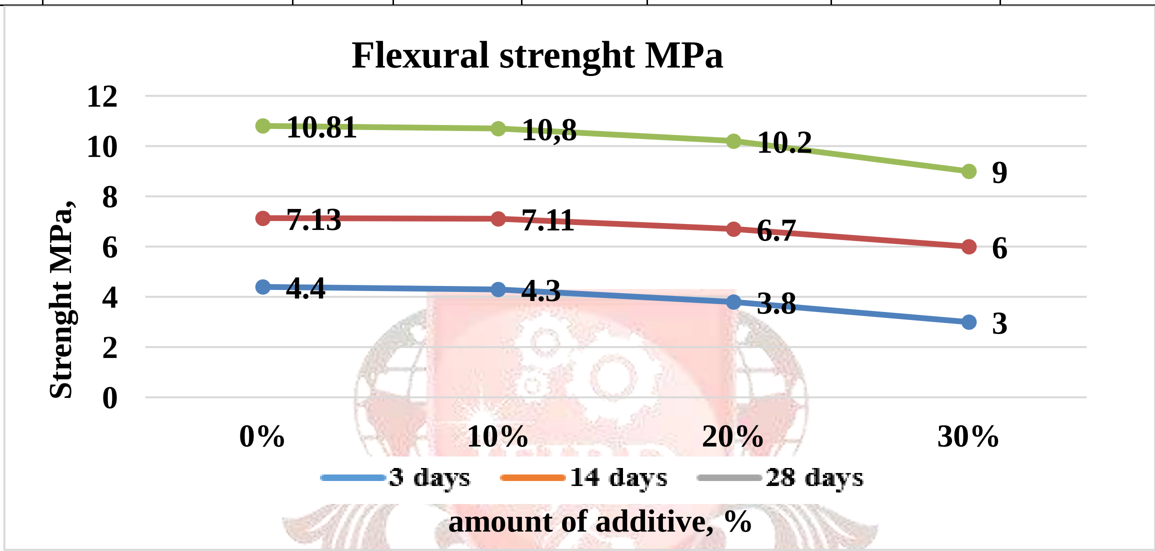

Figure 1. Influence of fly ash on bending properties of Portland cement

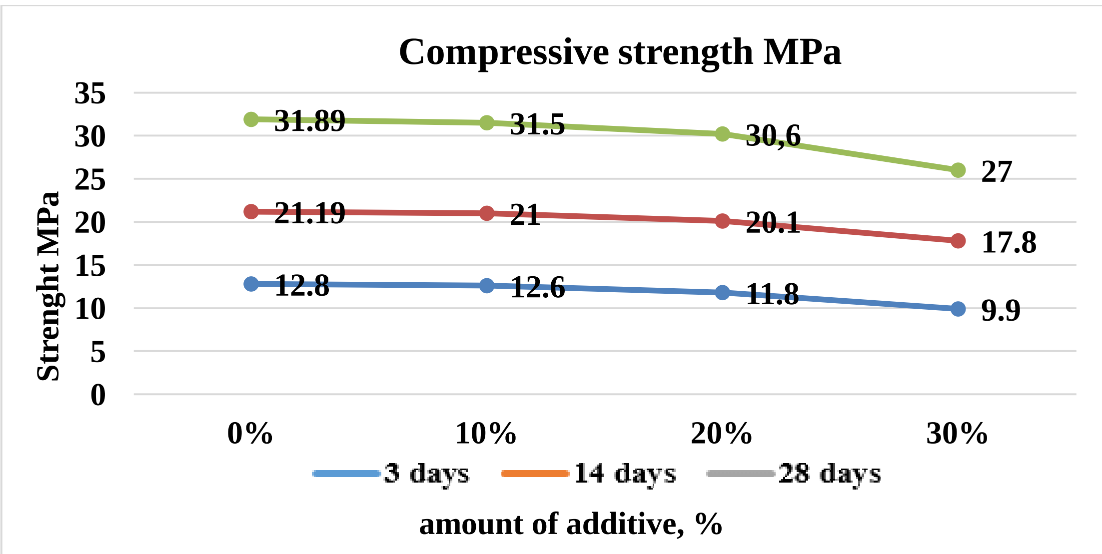

Figure 2. Influence of fly ash on the properties of Portland cement in compression

Table -4
Influence of copper smelter waste on the properties of Portland cement

№	Portland cement amount (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
						Bend, MPa	Compression MPa
1	500	1500	200	0,4	0	9,5	28,25
2	450	1500	200	0,4	5	9,2	28,1
3	400	1500	200	0,4	10	8,7	27,4
4	350	1500	200	0,4	15	8	25,7

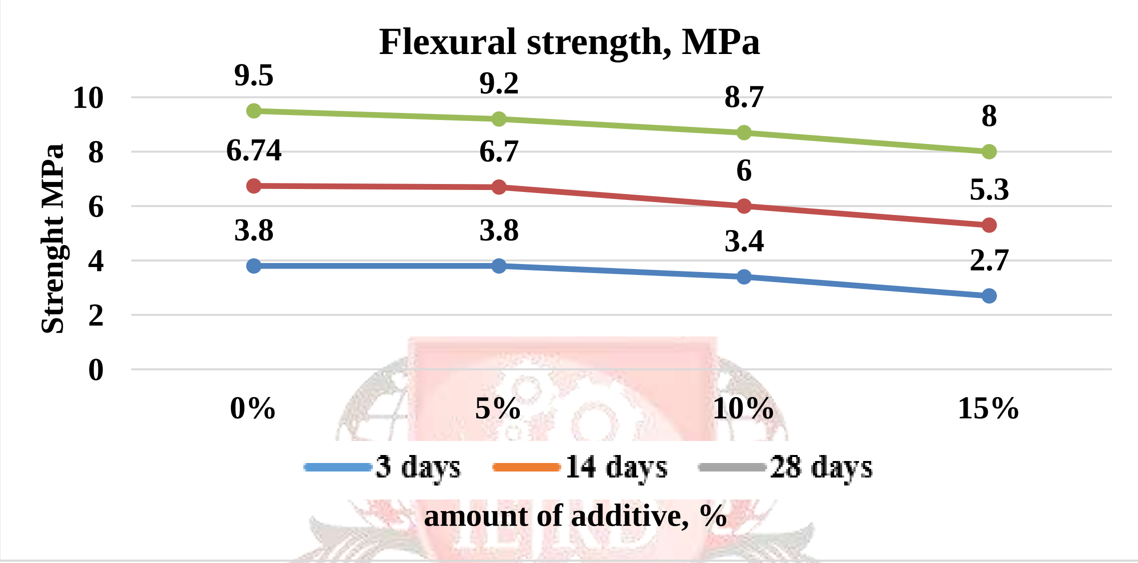

Figure 3. Influence of waste from the copper smelting industry on the bending properties of Portland cement

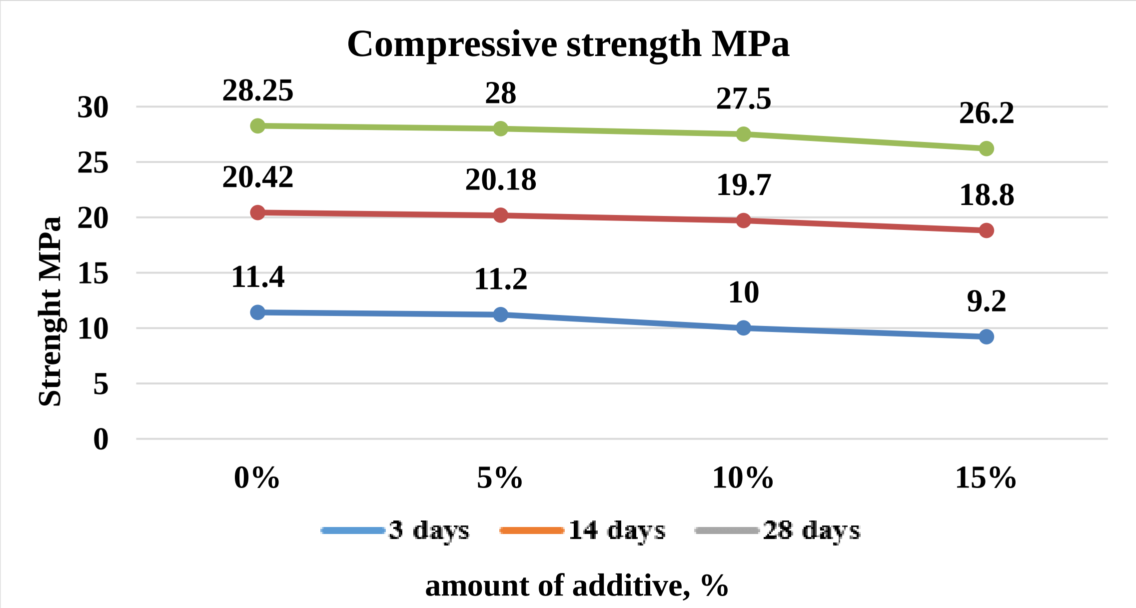

Figure 4. Influence of waste from the copper smelting industry on the properties of Portland cement in compression

Table-5
Flexural and compressive strength of samples made with the addition of a complex of fly ash and copper smelter waste.

№	Portland cement amount (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)		Strength	
					Fly ash	Waste from the copper smelting industry	Bend, MPa	Compression MPa
1	500	1500	200	0,4	0	0	9,5	27,3
2	450	1500	200	0,4	5	5	9,2	27,1
3	400	1500	200	0,4	15	5	9	26,4
4	350	1500	200	0,4	20	10	7,6	25,7

The above table shows the values in MPa of the flexural and compressive strength of a 3, 14 and 28-day cement mix made with the addition of a complex of fly ash and copper smelter waste as a mineral additive.

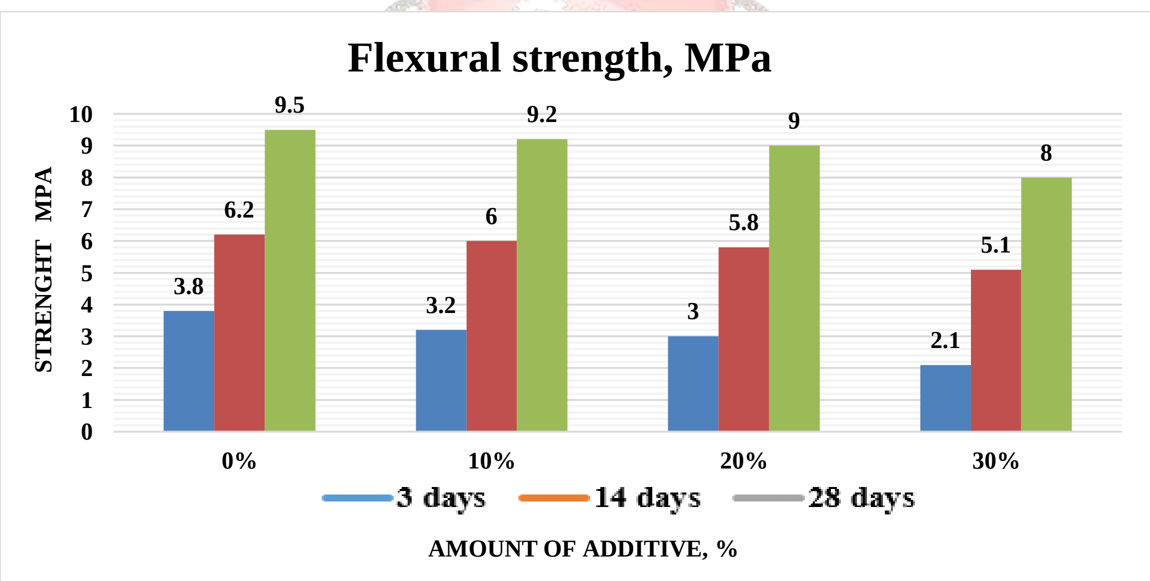

Figure 5. Influence on the flexural strength of specimens made with the addition of a complex of fly ash and copper smelter waste

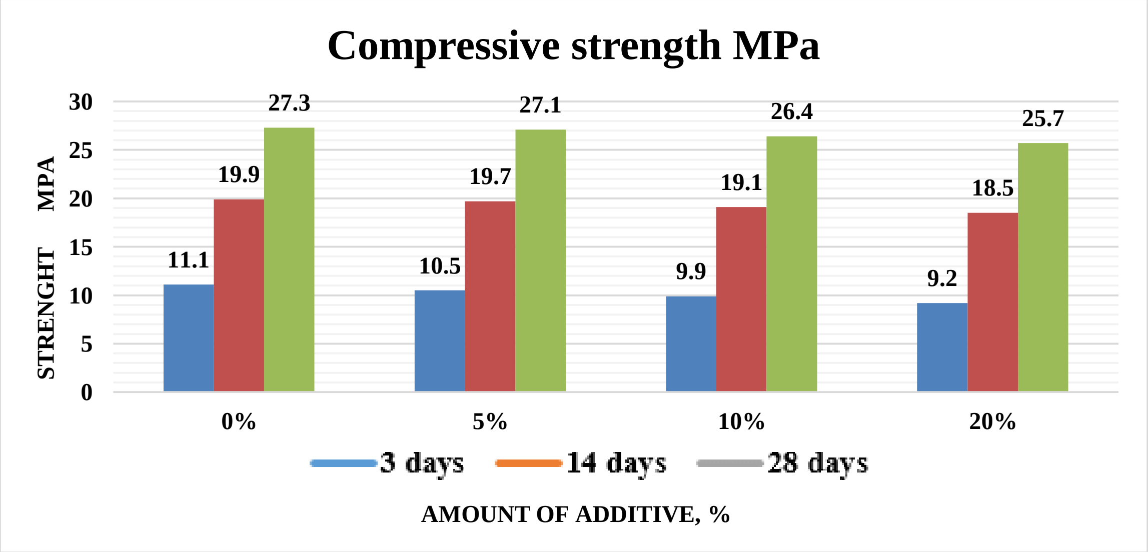

Figure 6. Influence on the compressive strength of samples made with the addition of a complex of fly ash and copper smelter waste

The above table shows the values of the flexural and compressive strengths of cement mixture samples made with the addition of fly ash and copper-smelting waste, based on these data, the optimal composition of the cement mixture with the addition of two mineral additives was selected. In the case when 15% fly ash and 5% copper smelter additive were added, and the total cement consumption (from the amount of binder) was changed by 20%, the strength of the mixture was higher than that of fly ash alone with a change of 20%.

The analysis of theoretical and practical works on this topic is carried out, the relevance of research work is studied. It is also related to the properties of the materials used in the production of high quality lightweight concrete. In this research work, the influence of materials used in the manufacture of high-quality cement mixtures, mainly Portland cement, mineral additives (fly ash and waste from the copper industry), on the properties of fine fillers - sand, water and cement paste is studied. {4}

After the selection of the optimal composition of the cement paste made with the addition of a complex of mineral additives, the properties of this mixture were studied with the addition of the superplasticizer "Beton Strong-17".

In the course of studying the properties of Bekabad PC400 and fly ash, using four different amounts of the chemical additive “Betong strong-17” in relation to the mass of cement, we selected the most optimal amount of the additive for us - 1%.

Table-6
Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

№	Portland cement amount (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
						Bend, MPa	Compression MPa
1	500	1500	200	0,4	0	5,6	40,5

2	500	1500	185	0,37	1	7,3	52

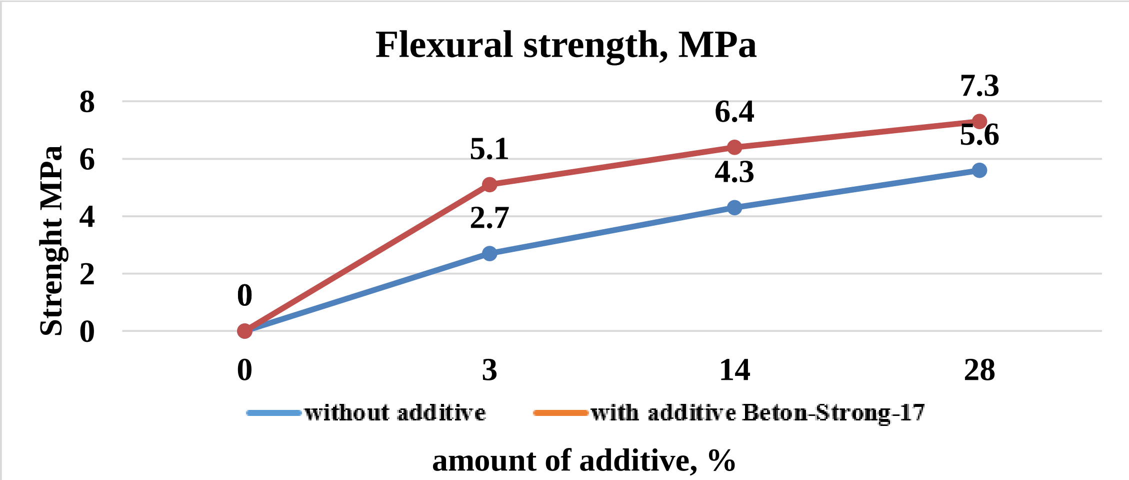

Figure 7. Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

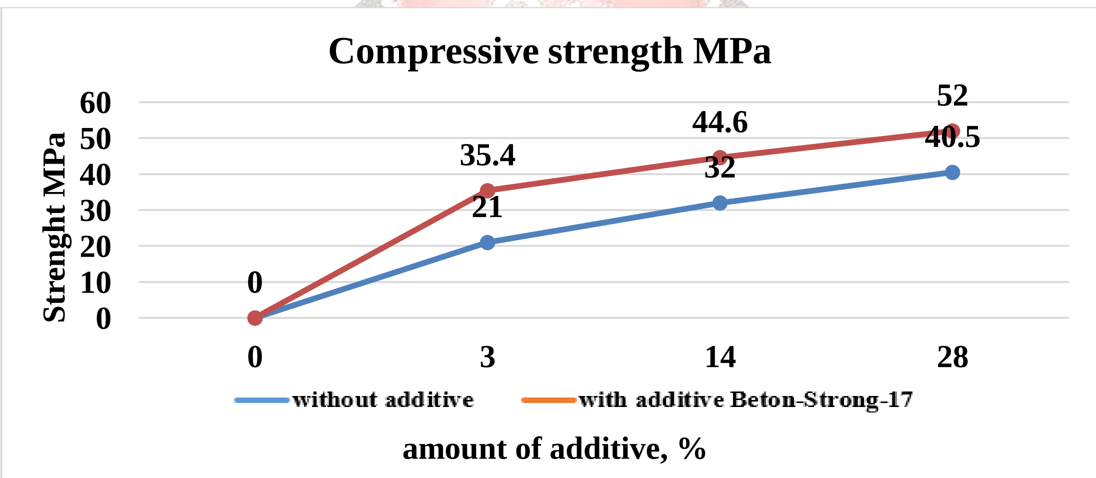

Figure 8. Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

Table-7

Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

№	Portland cement amount (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
						Bend, MPa	Compression MPa
1	500	1500	200	0,4	0	5,3	39,8
2	400	1500	128	0,32	1,0	5,6	40,5

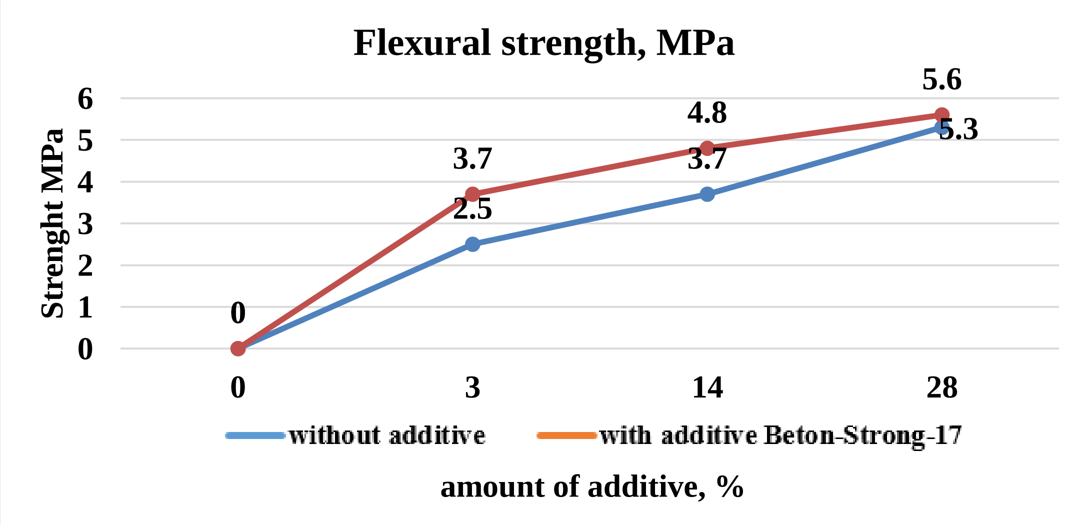

Figure 9. Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

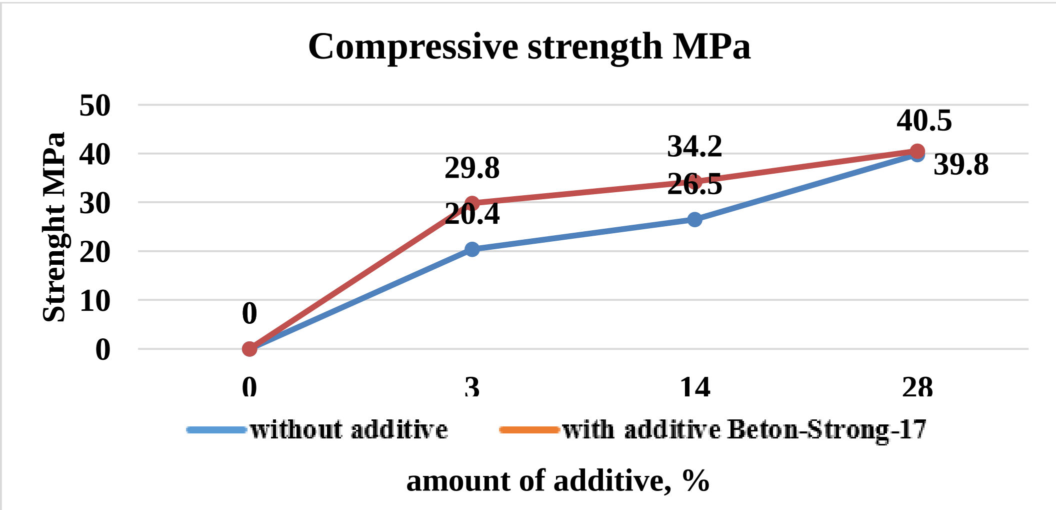

Figure 10. Influence of the superplasticizer "Beton Strong-17" on the properties of Portland cement

Table 8

Influence on the properties of Portland cement of mineral additives in the binder in the form of a complex of fly ash and copper industrial waste and superplasticizer "Beton Strong-17"

№	Binder amount (gr)			Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
	Portland cement 80%	Fly ash 15 %	Waste from the copper industry 5%					Bend, MPa	Compression MPa

1	500	1500	200	0,4	0	4,9	39,4
2	400	1500	128	0,32	1,0	5,7	41,9

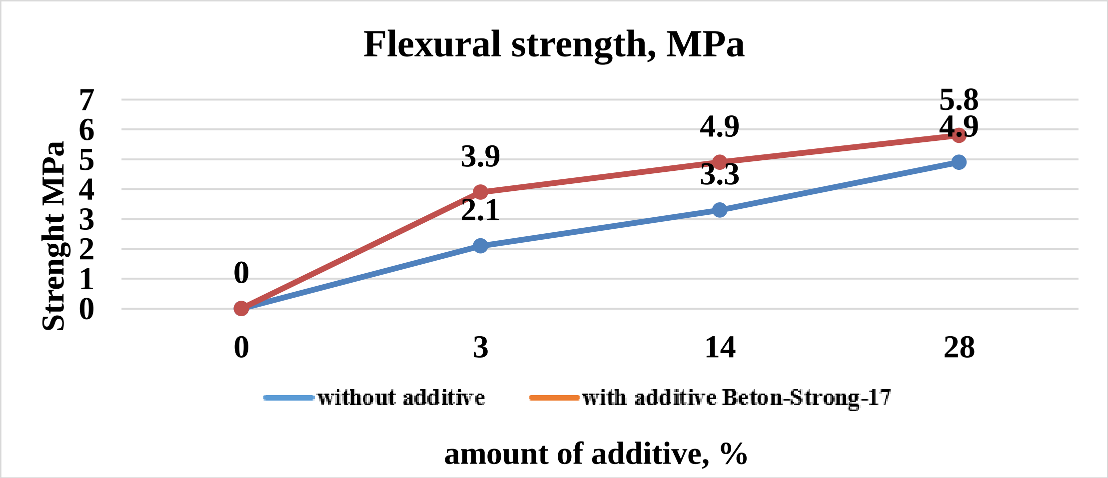

Figure 11. Influence of mineral additives and superplasticizer "Beton Strong-17" on the properties of Portland cement

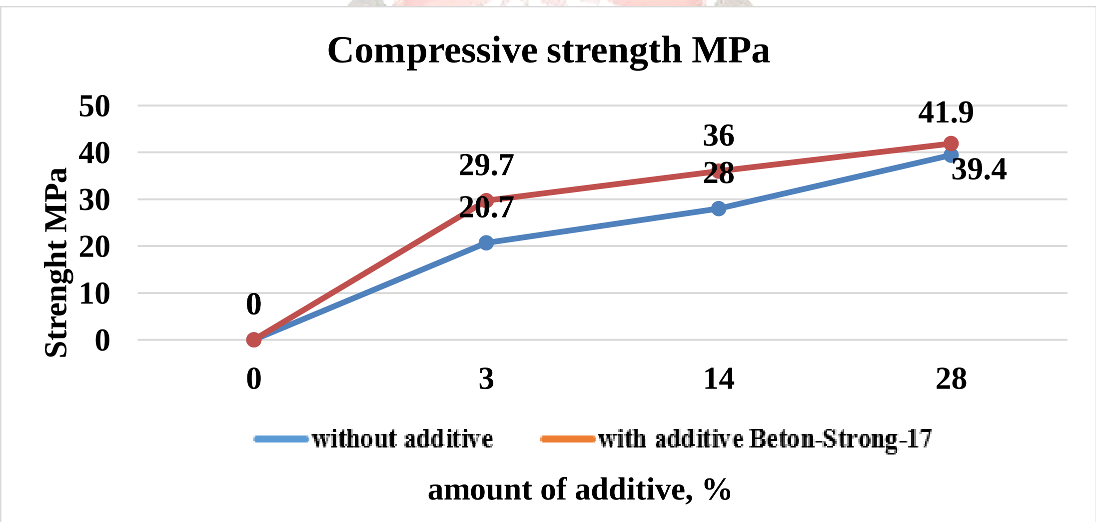

Figure 12. Influence of mineral additives and superplasticizer "Beton Strong-17" on the properties of Portland cement

In the course of scientific research, the effect of a chemical additive in a cement mixture made with the addition of a complex of binding mineral additives has been studied. With the addition of a chemical additive, the cement mixture acquired approximately 65–70% of the required strength in 3 days.

CONCLUSION

As a result of accelerating the hardening time of the cement mixture with this additive, the strength also increased. The indicators of economic efficiency have been determined: the consumption of cement per 1 m³ of concrete is 400 kg, with the complex use of mineral additives, 20% of the amount of binder can be saved by changing its composition, and not the amount of the binder, and the use of the chemical additive "Beton Strong-17" reduced the consumption of the binder (Portland cement) by 20% and provided the required strength.

At the same time: the price of 1 kg of Portland cement is 780 sum, 1 m³ of concrete requires 400 kg of Portland cement, the cost for this amount is 312,000 sum. The price of 1 kg of fly ash is 35 sum, with the introduction of 15% of the amount of binder, 60 kg of fly ash will be required, its cost will be 2,100 sum. And the price of 1 kg of waste from the copper industry is 25 sum, with the introduction of them in the amount of 5% of the total amount of binder, the cost of 20 kg of industrial copper waste will be 500 sum.

In turn, the cost of a binder (Portland cement) per 1 m³ of concrete is 312,000 sum, and the cost of a complex binder based on mineral additives is: 80 kg of Portland cement - 62,400 sum, 80 kg of mineral additives - 2,600 sum, of which 60 kg of fly ash - 2,100 sum, 20 kg of waste from the copper industry - 500 sum (312,000 - 62400 = 249600 sum. When adding the cost of mineral additives (2600 sum) to the price of this Portland cement (249600 sum), the total cost will be 252200 sums. The indicator of the economic efficiency of the mineral additive from the cost of the binder material (Portland cement) for each 1 m³ of concrete amounted to 59 800 sum.

With the addition of a chemical additive, we save 20% of 400 kg of binder used to make 1 m³ of concrete, if 252,200 sum were spent on a complex binder containing mineral additives, then this cost is further reduced by 11240 sum (20%). Moreover, if the price of 1 kg of a chemical additive is 9800 sum, the cost per 1 m³ of concrete will be 39,200 sum. The general indicator of economic efficiency when using together mineral and chemical additives was due to the cost of the binder 71040 sum per 1 m³ of concrete.

The addition of a complex of mineral additives and a chemical additive Beton Strong-17 increases the durability, strength and frost resistance of concrete, allowing it to work even at temperatures of 0 ... - 10^0C.

This study is relevant, designed to improve the performance properties of building cement mixtures by adding chemical and complex modifying mineral active additives based on industrial waste proposed by the author.

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