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Study Chemical Additives Polyplast C-3 on the Properties of Portland cement with Mineralogic Components

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Abstract: 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 are superplasticizers. Below are considered the most important physical and mechanical characteristics of cement kiln, which can be influenced by the introduction of additives. This will serve as a basis for understanding the behavior of cement, concrete mix and concrete obtained with the use of different types of additives, which will be devoted to the following chapters.

Keywords: Chemical additives, water-cement ratio, derate cement calculation, mechanical properties of binders.

I. INTRODUCTION.

Water-reducing agents are additives that reduce the amount of water required to provide a concrete mix with the same fluidity as a conventional mix. These additives improve the properties of hardening concrete and, in particular, increase its strength and durability. Usually, according to the standard, the reduction in the amount of water mixing should be at least 5%, however, technical additives-water-depleted can reduce water demand by 10-15%.

There are other reasons for using such additives, including the possibility of simultaneously lowering the content of both water and cement while maintaining the workability of the mixture and the strength of the concrete at the same level as the control portions of the mixture and concrete. Therefore, in this case, the additives additionally reduce the cement consumption. In addition, they are able to reduce the rate of heat release during cement hydration - a property that is important when concreting in hot climates or when erecting massive structures.

If these additives are introduced while maintaining the water-cement ratio, then the "workability" of the concrete mixture is improved, i.e. such additives should be considered plasticizers. This is especially important when placing concrete mix in a structure with a high coefficient of reinforcement where increased mix mobility is required.

II. 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.,

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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.

III. 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 ($3CaO \cdot SiO_2$ and $2CaO \cdot SiO_2$ 70-80%).

Although the study of the hydration of pure cement constituents is in itself useful for tracing hydration processes in Portland cement, it cannot be directly applied to cements due to the complexity of the reactions taking place. In Portland cement, minerals do not consist of pure phases: they are solid solutions containing Al, Mg, Na, etc. The study of the hydration of alite containing different amounts of Al, Mg or Fe showed that with the same degree of hydration of Fe, alite achieves greater strength.

In this graph, you can see the chemical elements and their ratio in the composition of Portland cement in the 500 grade.

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Analyzed result(FP method, Scatter)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ
1	Cl	0.0503	mass%	0.0003	0.0001	0.0004
2	Mg	0.749	mass%	0.0102	0.0144	0.0433
3	Al	1.66	mass%	0.0067	0.0071	0.0213
4	Si	9.89	mass%	0.0099	0.0007	0.0020
5	S	1.01	mass%	0.0015	0.0015	0.0046
6	K	0.769	mass%	0.0055	0.0046	0.0137
7	Ca	51.0	mass%	0.0519	0.0024	0.0072
8	Ti	0.128	mass%	0.0024	0.0036	0.0107
9	Cr	(0.0021)	mass%	0.0004	0.0012	0.0035
10	Mn	0.134	mass%	0.0021	0.0014	0.0041
11	Fe	2.59	mass%	0.0057	0.0023	0.0070
12	Cu	0.0041	mass%	0.0002	0.0004	0.0013
13	Zn	0.0030	mass%	0.0002	0.0003	0.0009
14	As	0.0013	mass%	<0.0001	0.0002	0.0006
15	Rb	0.0038	mass%	<0.0001	<0.0001	0.0003
16	Sr	0.0637	mass%	0.0003	0.0002	0.0007
17	Y	0.0040	mass%	<0.0001	0.0001	0.0003
18	Zr	0.192	mass%	0.0018	0.0007	0.0020
19	Ba	0.0255	mass%	0.0009	0.0019	0.0057
20	Pb	0.0017	mass%	0.0001	0.0003	0.0008

Spectrum

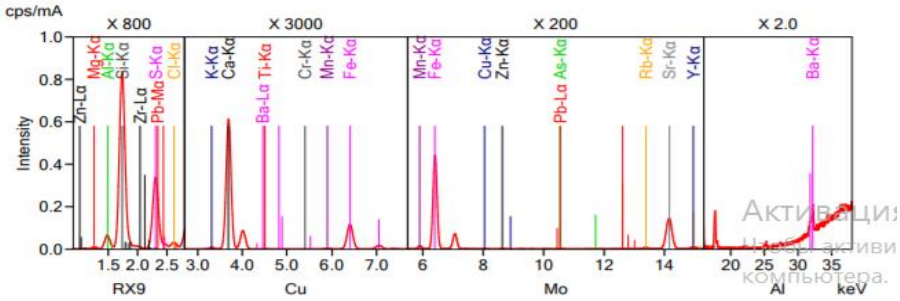

Figure-1. Chemical oxide-elemental composition Portland Cement CEM-1 42,5N

b) chemical additives:

Plasticizer C-3 has excellent plasticizing properties and effective water-reducing action.

Pastifier C-3 is applicable for light and heavy ready-mixed concrete and for the production of prefabricated structures from high-strength concrete B20 and higher, pressure reinforced concrete pipes, for the manufacture of densely reinforced structures (such as trusses, beams, columns, bridge spans), slabs and panels at stands in cassettes, on flow-aggregate and conveyor lines, in the construction of critical structures of monolithic structures with an increased degree of reinforcement and a complex configuration.

The feasibility of using a plasticizing additive is determined by the achievement of various technological indicators of efficiency in the production of reinforced concrete products and structures, the construction of structures, as well as indicators of economic efficiency during their operation.

The use of the additive allows you to achieve the following indicators:

- increase the overall concrete mobility from P1 to P5;
- reduce water consumption when mixed with a binder by 20 - 25%;
- increase the strength and reliability of the final product by 25% or more (in equal-motion mixtures);
- increase the adhesion of embedded reinforcement and metal products to concrete by 1.5 - 1.8 times;
- to obtain products with reduced moisture absorption and increased crack resistance, frost resistance (up to 350 repeated annual cycles);

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- reduce the total cement consumption by up to 25%.

Analyzed result(FP method)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ
1	Total	885	mg/cm2			
2	Cl	172	ppm	3.08	5.11	15.3
3	H2O	83.6	mass%			
4	Al2O3	7270	ppm	425	955	2870
5	SiO2	1610	ppm	82.3	178	534
6	P2O5	384	ppm	23.0	55.4	166
7	SO3	154000	ppm	196	4.75	14.3
8	K2O	228	ppm	11.1	17.4	52.3
9	CaO	96.9	ppm	6.31	11.1	33.4
10	Cr2O3	(2.34)	ppm	0.577	1.48	4.45
11	MnO	(10.6)	ppm	2.71	6.90	20.7
12	Fe2O3	618	ppm	8.48	4.81	14.4
13	CuO	10.2	ppm	0.760	1.48	4.43
14	Ag2O	7.90	ppm	0.714	1.24	3.72
15	SnO2	29.1	ppm	1.75	3.46	10.4
16	TeO2	24.3	ppm	2.53	6.46	19.4
17	U3O8	(1.44)	ppm	0.352	0.989	2.97

Spectrum

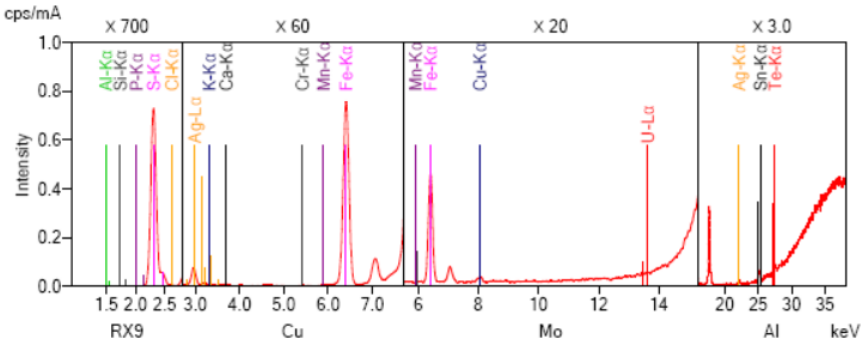
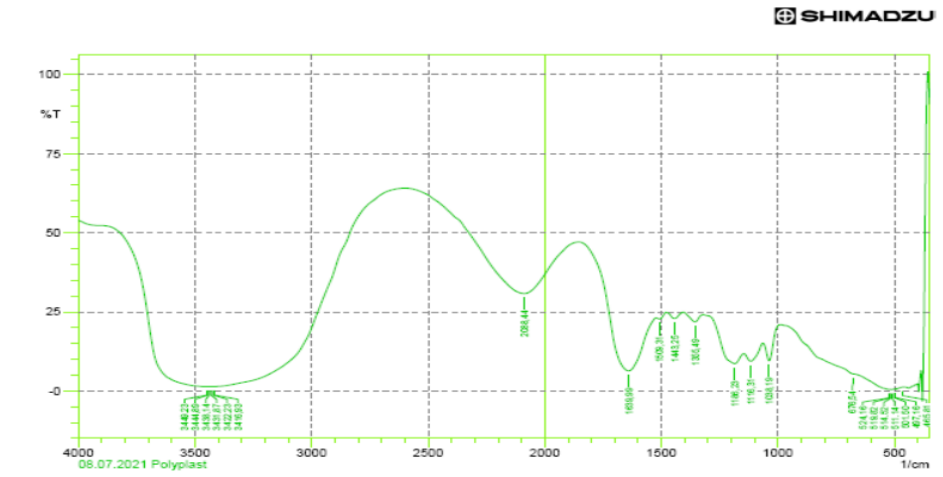


Figure-2. Chemical oxide-elemental composition chemical additives Poly Plast C-3



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	465,81	1,18	0,02	466,78	463,88	5,56	0,01
2	497,16	0,58	0,03	498,6	494,26	9,64	0,05
3	501,5	0,57	0,02	502,46	499,09	7,55	0,02
4	511,14	0,42	0,04	512,59	503,91	19,96	0,08
5	514,52	0,44	0,02	517,89	513,07	11,31	0,03
6	519,82	0,47	0,01	521,75	518,37	7,84	0,03
7	524,16	0,48	0,01	525,61	522,23	7,82	0,02
8	676,54	5,34	0,08	991,42	675,09	297,38	0,04
9	1038,19	9,52	7,73	1064,72	991,9	61,1	6,68
10	1116,31	9,39	3,64	1145,73	1065,2	76,58	6,24
11	1186,23	8,63	5,99	1321,73	1146,21	148,85	15,05
12	1365,49	21,82	2,62	1405,64	1322,21	52,91	1,99
13	1443,25	22,91	1,99	1478,93	1406,12	45,26	1,3
14	1509,31	22,75	0,93	1522,81	1480,86	26,46	0,44
15	1639,99	6,34	25,22	1855,05	1523,29	236,74	78,15
16	2088,44	30,79	21,68	2593,31	1855,54	256,69	65,08
17	3416,93	1,39	0,11	3418,37	2602,48	686,39	0,98
18	3422,23	1,38	0	3423,19	3418,85	8,06	0
19	3431,87	1,37	0	3432,84	3425,12	14,35	0
20	3438,14	1,37	0,01	3440,07	3435,25	8,98	0,01
21	3444,89	1,37	0	3446,34	3440,55	10,78	0
22	3449,23	1,37	0,01	3457,43	3446,82	19,75	0,01

Figure-3. Infrared spectrogram analysis of chemical additives Poly Plast C-3

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c) 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.

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.

Analyzed result(FP method, Scatter)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ
1	Mg	1.77	mass%	0.0208	0.0312	0.0937
2	Al	18.3	mass%	0.0287	0.0099	0.0298
3	Si	36.9	mass%	0.0282	0.0026	0.0079
4	S	5.80	mass%	0.0076	0.0009	0.0026
5	K	2.85	mass%	0.0202	0.0130	0.0389
6	Ca	16.2	mass%	0.0365	0.0119	0.0358
7	Ti	1.64	mass%	0.0090	0.0082	0.0247
8	V	0.0709	mass%	0.0029	0.0077	0.0230
9	Cr	0.0098	mass%	0.0010	0.0026	0.0077
10	Mn	0.361	mass%	0.0050	0.0058	0.0175
11	Fe	14.1	mass%	0.0223	0.0038	0.0115
12	Co	(0.0335)	mass%	0.0039	0.0116	0.0348
13	Ni	(0.0037)	mass%	0.0006	0.0014	0.0042
14	Cu	0.0283	mass%	0.0008	0.0010	0.0030
15	Zn	0.134	mass%	0.0014	0.0009	0.0028
16	Ga	0.0159	mass%	0.0005	0.0007	0.0020
17	Ge	0.0020	mass%	0.0002	0.0005	0.0015
18	As	0.0375	mass%	0.0006	0.0010	0.0029
19	Se	0.0026	mass%	0.0002	0.0003	0.0009
20	Rb	0.0476	mass%	0.0004	0.0003	0.0009
21	Sr	0.421	mass%	0.0011	0.0002	0.0007
22	Y	0.0216	mass%	0.0003	0.0005	0.0015
23	Zr	0.669	mass%	0.0055	0.0017	0.0050
24	Nb	0.0113	mass%	0.0009	0.0014	0.0042
25	Ag	0.0022	mass%	0.0004	0.0007	0.0020
26	Sn	0.0064	mass%	0.0006	0.0011	0.0034
27	Ba	0.329	mass%	0.0043	0.0056	0.0167
28	Re	(0.0095)	mass%	0.0030	0.0090	0.0270
29	Ir	(0.0032)	mass%	0.0011	0.0030	0.0091
30	Pt	(0.0031)	mass%	0.0008	0.0023	0.0068
31	Au	0.0057	mass%	0.0007	0.0017	0.0052
32	Pb	0.0301	mass%	0.0011	0.0029	0.0087
33	Eu	0.118	mass%	0.0111	0.0315	0.0945
34	Ac	0.0110	mass%	0.0005	0.0014	0.0041
35	U	0.0083	mass%	0.0004	0.0012	0.0035

Spectrum

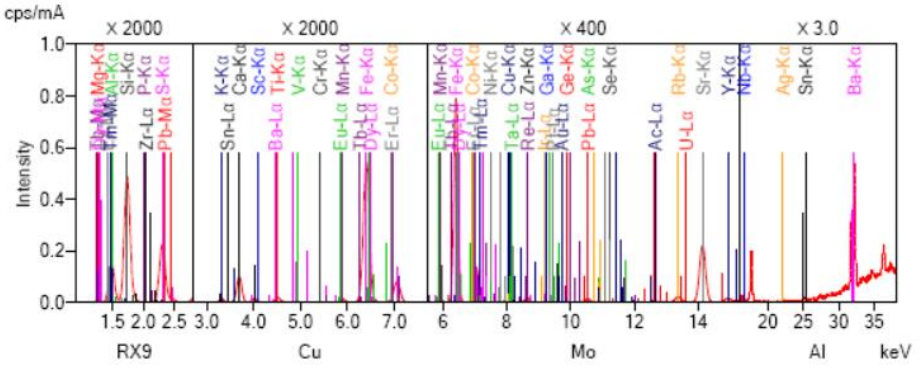

Figure 4. Spectral analysis of fly ash

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IV. RESULT AND DISCUSSION

When studying the effect of additives on the properties of cement compositions, a factorial design of the experiment was implemented, in which the x-dosage of the additive, varying from 0 to 2%, based on the weight of cement, was taken as a significant factor. Normal density and setting time are taken as responses for the cement paste; for cement stone bending and compressive strength.

Additives were added at a concentration of 0 to 2%. Data of cement tests with the addition of PolyPlast for a period of 3.7 and 28 days.

Table 1. *Influence of the chemical additive PolyPlast on the normal density cement paste.*

№	Name	Control sample	Amount of chemical additives (%)				
1	PoliPlast	0	0,5	1,0	1,5	2,0	2,5
	Amount of water (%)	27	25	24	23	22	25
	results (мм)	6,8	6,0	6,0	6,4	6,8	24,5

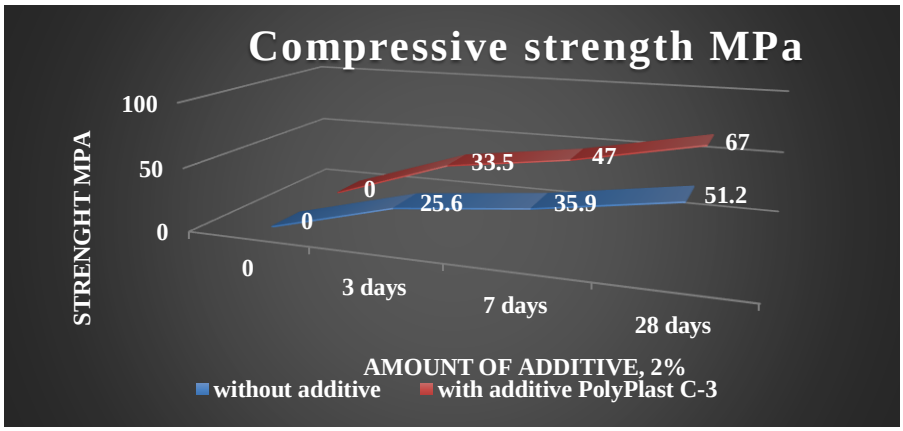

Figure 5. Influence of the plasticizer "PolyPlast C-3" on the properties of Portland cement

According to the data, it can be seen that the ultimate strength of 3,7 and 28 days is the highest for cement with an additive introduced in an amount of 2%, it were for 3 days R_{ban} 1,8MPa R_{com} 33,5MPa, for 7 days R_{ban} 2,35MPa R_{com} 47MPa and for 28 days R_{ban} 3,35MPa R_{com} 67MPa. If we compare these results with the result of the control sample, we can see that, these results give up the opportunity to save cement consumption up to 25 and 30%.

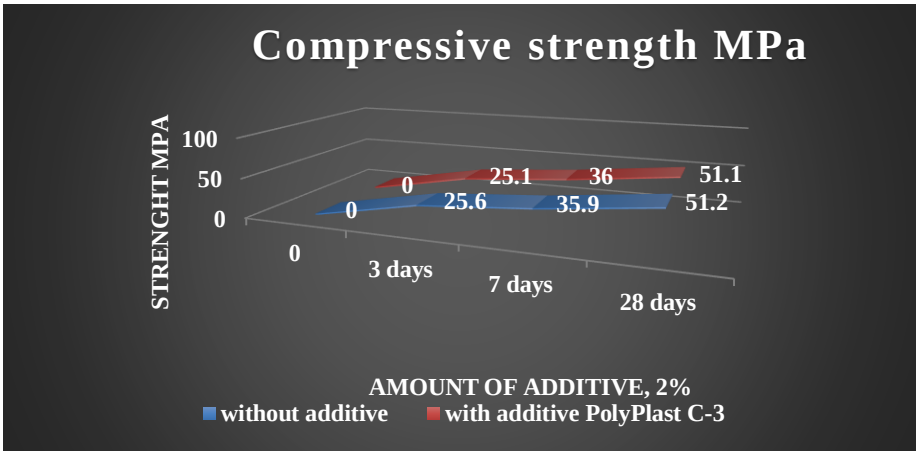

Figure 6. Influence of the plasticizer "PolyPlast C-3" on the properties of Portland cement

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Going out these hypotheses, we have made experiments relating to the cement and achieved a good result. Experiments were held 3,7 and 28 days and the result were full expected. Results were for 3 days R_{ban} 1,3MPa R_{com} 25,1MPa, for 7 days R_{ban} 1,82MPa R_{com} 36MPa and for 28 days R_{ban} 2,5MPa R_{com} 51,1MPa.

Table-2. *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	CompressionMPa
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

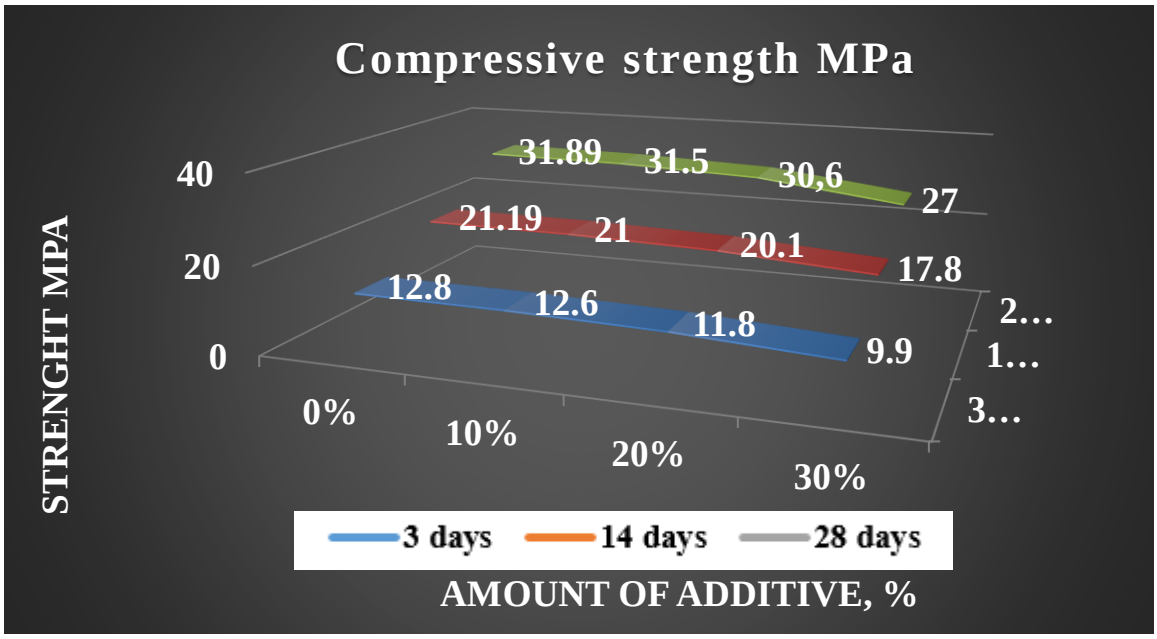

Figure 7. Influence of fly ash on the properties of Portland cement in compression

Table-3. *Influence on the properties of Portland cement of mineral additives in the binder in the form of a complex of fly ash and superplasticizer "Poly Plast C-3*

№	Binder	Amount of binder (gr)	Sand (gr)	Water (ml)	W / C (%)	Additive amount (%)	Strength	
							Flexural MPa	Compressive MPa
1	Portland Cement	500	1500	200	0,4	0	6,1	53,6
2	Portland Cement	500	1500	150	0,3	2	7,3	57,4
3	Portland Cement	400	1500	150	0,3	2	6,0	52,4
4	Portland Cement + Fly ash	325 175	1500	235	0,47	0	5,4	41,3
5	Portland Cement + Fly ash	325	1500	196	0,39	2	6,8	56,3

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		175						
6	Portland Cement + Fly ash	260 140	1500	196	0,39	2	6,3	53,5

V. 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 ... - 100C.

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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