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Influence Of Plastifying Additives On The Properties Of Cement Stone

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Abstract The article presents the results of research work on the development of the properties of binders with chemical additives and determines the optimal compositions.

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. The most important physical and mechanical characteristics of cement with chemical additives are discussed below.

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

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.

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

The main phases of Portland cement clinker are tricalcium aluminate 3CaO · SiO2, dicalcium silicate 2CaO · SiO2, tricalcium aluminate 3CaO · Al2O3 and a ferrite phase of the average composition 4CaO Al2O3 Fe2O3. In industrial clinkers, they are not present in pure forms.

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 oxide analyzes in 500 Portland cement.

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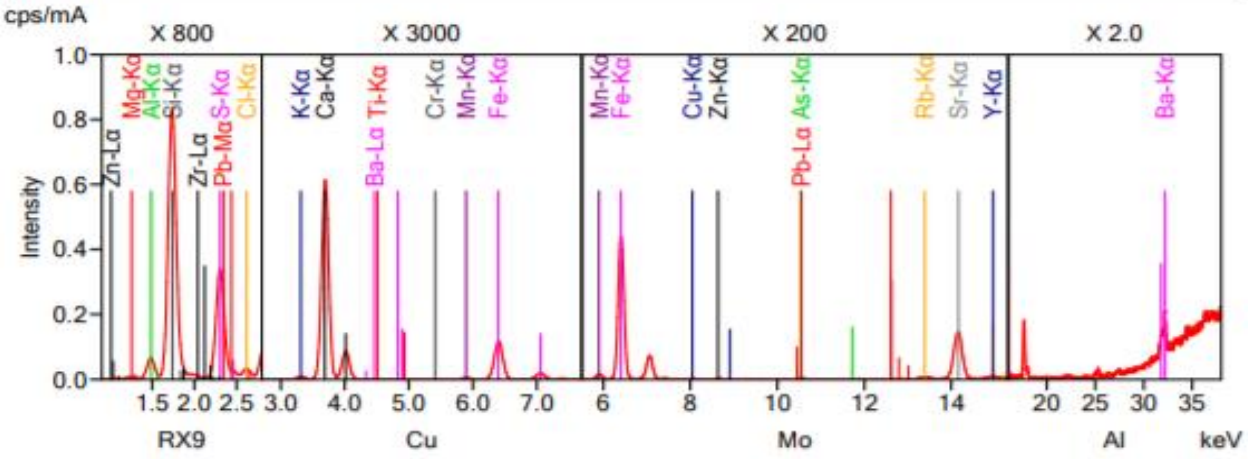
Analyzed result(FP method, Scatter)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ
1	Cl	0.0478	mass%	0.0003	0.0001	0.0004
2	MgO	1.19	mass%	0.0160	0.0230	0.0689
3	Al2O3	2.99	mass%	0.0118	0.0128	0.0385
4	SiO2	20.2	mass%	0.0171	0.0005	0.0016
5	SO3	2.39	mass%	0.0036	0.0036	0.0109
6	K2O	0.855	mass%	0.0064	0.0068	0.0203
7	CaO	65.7	mass%	0.0474	0.0151	0.0454
8	TiO2	0.202	mass%	0.0035	0.0048	0.0145
9	Cr2O3	(0.0030)	mass%	0.0006	0.0016	0.0048
10	MnO	0.159	mass%	0.0025	0.0016	0.0049
11	Fe2O3	3.43	mass%	0.0075	0.0031	0.0093
12	CuO	0.0047	mass%	0.0003	0.0005	0.0014
13	ZnO	0.0034	mass%	0.0002	0.0003	0.0010
14	As2O3	0.0016	mass%	0.0001	0.0002	0.0007
15	Rb2O	0.0038	mass%	<0.0001	<0.0001	0.0003
16	SrO	0.0696	mass%	0.0003	0.0002	0.0007
17	Y2O3	0.0047	mass%	<0.0001	0.0001	0.0004
18	ZrO2	0.241	mass%	0.0022	0.0009	0.0026
19	BaO	0.0270	mass%	0.0010	0.0020	0.0061
20	PbO	0.0017	mass%	0.0001	0.0003	0.0008

Spectrum



b)chemical additives:

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

Pastifier S-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.

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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);

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

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

Table 2.

Effect of the chemical additive PolyPlast on the setting time cement paste.

№	Name	Control sample	Amount of chemical additives (%)				
			0,5	1,0	1,5	2,0	2,5

1	The beginning of the setting time	65	70	85	90	100	70
2	End of setting time	340	325	310	290	280	295

Table 3

Strength characteristics of PC 500 A0 for 3 days. with addition PolyPlast C-3

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	1,28	25,6
2	500	1500	240	0,45	0,5	1,4	28
3	500	1500	240	0,43	1,0	1,55	31
4	500	1500	240	0,4	1,5	1,75	33
5	500	1500	192	0,38	2,0	1,8	33,5

Table 4

Strength characteristics of PC 500 A0 for 7 days. with addition PolyPlast C-3

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	1,8	35,9
2	500	1500	240	0,45	0,5	1,9	39,2
3	500	1500	240	0,43	1,0	2,17	43,4
4	500	1500	240	0,4	1,5	2,3	46,2

5	500	1500	192	0,38	2,0	2,35	47

Table 5

Strength characteristics of PC 500 A0 for 28 days. with addition PolyPlast C-3

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	2,6	51,2
2	500	1500	240	0,45	0,5	2,6	56
3	500	1500	240	0,43	1,0	3,1	61,9
4	500	1500	240	0,4	1,5	3,3	66
5	500	1500	192	0,38	2,0	3,35	67

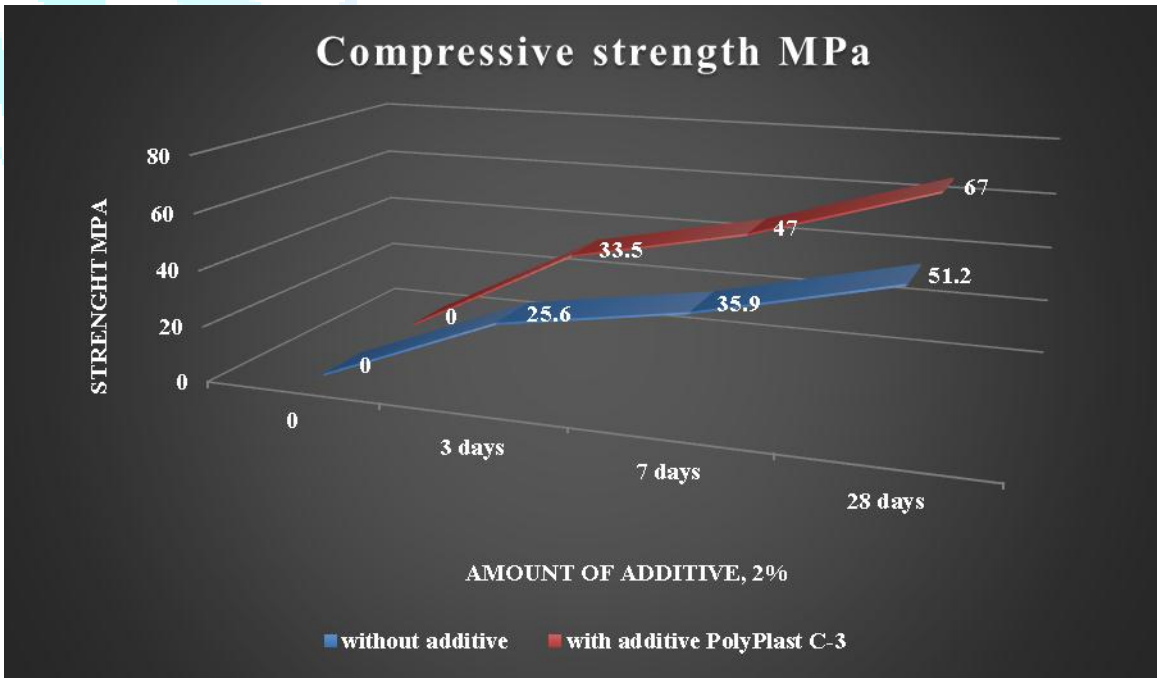

Figure 1. Influence of the plasticizer "PolyPlast C-3" on the properties of Portland cement

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%.

Table 6

Strength characteristics of PC 500 A0 for 3 days. with addition PolyPlast C-3 when amount of cement was decreased step by step

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	1,28	25,6
2	450	1500	240	0,45	0,5	1,16	22,7
3	400	1500	240	0,43	1,0	1,22	24,2
4	360	1500	240	0,4	1,5	1,26	24,6
5	350	1500	192	0,38	2,0	1,3	25,1

Table 7

Strength characteristics of PC 500 A0 for 7 days. with addition PolyPlast C-3 when amount of cement was decreased step by step

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	1,8	35,9
2	450	1500	240	0,45	0,5	1,71	32,31
3	400	1500	240	0,43	1,0	1,73	35,1
4	360	1500	240	0,4	1,5	1,7	35,8

5	350	1500	192	0,38	2,0	1,82	36

Table 8

Strength characteristics of PC 500 A0 for 28 days. with addition PolyPlast C-3 when amount of cement was decreased step by step

№	Portland cement (gr)	Sand (gr)	Water (ml)	C/W (%)	Amount of additives (%)	Strength	
						Bend MPa	Compression MPa
1	500	1500	240	0,48	0	2,6	51,2
2	450	1500	240	0,45	0,5	2,34	45,6
3	400	1500	240	0,43	1,0	2,4	52,4
4	360	1500	240	0,4	1,5	2,44	51,9
5	350	1500	192	0,38	2,0	2,5	51,1

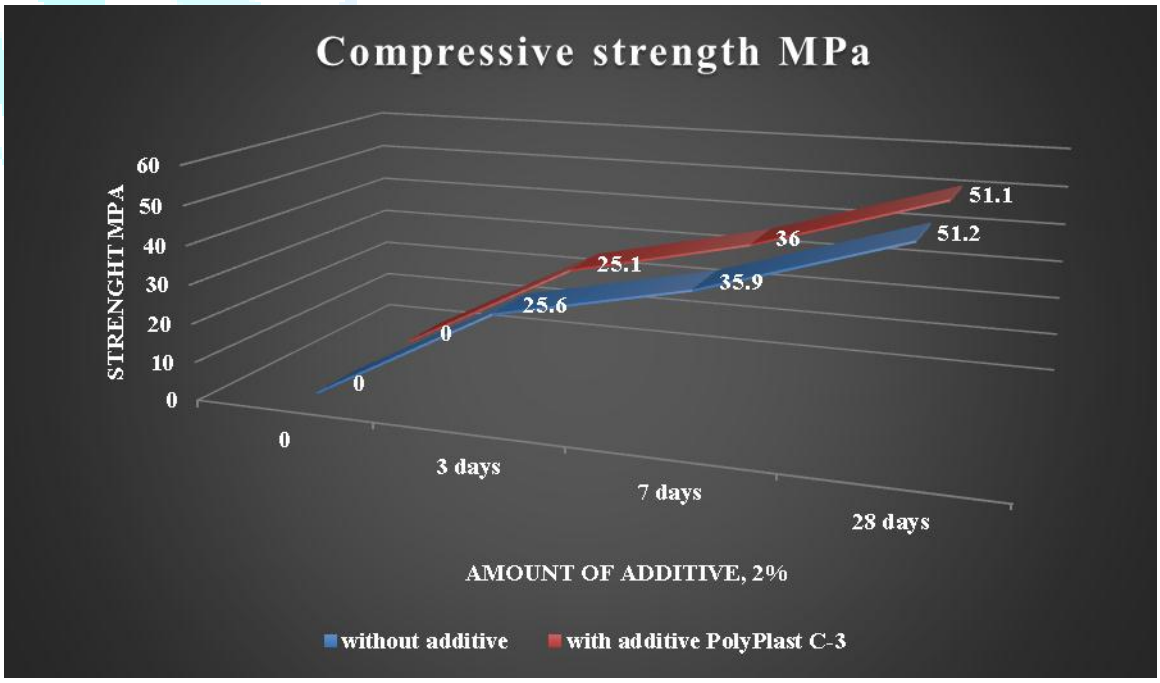

Figure 2. Influence of the plasticizer "PolyPlast C-3" on the properties of Portland cement

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.

Conclusion

As a result of experiments, placificating additives made it possible to reduce water and extend the setting time. Even when the strength was determined the strength was increased due to the lowering of the water-cement ratio. In addition due to the active properties of chemical additives, we can decreased consumption of Portland cement and maintain the strength of cement stone.

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