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INFLUENCE OF SUPERPLASTICIZER ON STRUCTURE FORMATION OF CEMENT STONE IN SALT MEDIUM

PHD, associate professor D. SHABANOV; I. ILMYRADOV; S. MATNIYAZOV
(Polotsk state university)

The article discusses issues of improving the performance characteristics of concrete by adding superplasticizer to the structure of cement stone. The effect of superplasticizer on the formation of the structure of cement paste, on flexural strength, and also on corrosion resistance. The general state of the problem of protecting reinforced concrete elements from aggressive external influence is described. The article builds a response surface from the dependencies obtained. The task of the construction industry is to maximize the economy of material assets and technological energy consumption in the production of constructional works, with ensuring the maintenance and performance characteristics of structures. One of the most important ways to improve productivity in construction, aside to using modern equipment, is the addition of chemical admixtures for various purposes.

***Keywords*:** *cement, salt, additives, corrosion, superplasticizer, response surface.*

Task formulation. The study of various chemical admixtures and their effect on cement stone. Chemical additives are those ingredients in concrete, other than the binder, water, and aggregates that are added to the mixture immediately before or during mixing. The development of ideas concerning the mechanism of additives is inextricably linked with the progress in the theory of hydration and hardening of mineral binders. In addition, research related to the rational economy of heat treatment of reinforced concrete structures is very relevant, but they require the optimal class of the additive with its optimization with mineral binders.

The effectiveness of additives depends on factors such as its composition, the rate of addition, adding time, type, brand and amount of cementing materials, water content, total shape, gradation and proportions, mixing time, recession or sediment of concrete, and temperature of concrete.

Introduction. What is in common between people lives and any kinds of buildings. The answer is Trust. The trust based on ‘‘strong and steady structure’’ The introduction of superplasticizer significantly increases the strength of cement stone by 75% compared with the control [1–5]. The study of chipped cement stone showed that, as part of a complex modifier, crystalline tumors form much less dispersion than in the composition without an additive. The introduction of a superplasticizer was followed by a change in the structure formation of the cement, both in the general structure of the cement stone and in the defective areas of the spatial skeleton, the decrease in porosity leads to the hardening of the material. In other words, by adding a superplasticizer to the structure of the cement stone, we get more closed pores than the open, as a percentage. Currently widely used additives that improve the laying of concrete. Depending on their effectiveness, they are called plasticizers and superplasticizers. The use of these additives can reduce material costs and improve the properties of the concrete used.

In [6], the authors investigated the use of superplasticizers in severe climatic conditions. The problem of producing durable and resistant to aggressive environments of concrete is relevant to this day. These types of concrete are mainly used for lining buildings.

Structuring hardened cement paste, which has a high density, low capillary porosity is the highest priority [1–4]. One of the effective methods of improving cement is the introduction of complex impurities, which contains effective superplasticizers and active mineral additives. An effective superplasticizer is an important part of concrete.

Additive superplasticizer allows not only to increase the consistency of concrete, but also to obtain high-strength concrete with high density. Basically the most advanced superplasticizing additives based on polycarboxylic ethers are the most effective. Also, by introducing water-repellent impurities, it is possible to achieve an increase in frost resistance, water resistance and external resistance. Silicone waters based on sodium and potassium silicates are important. In addition, it is necessary to take into account the slowing down of the hydration of cement in high doses of the water-repellent agent due to the hydrophobic film that occurs on the surface of the reactants and prevents the hydration process in the initial period. The aim of the study is to study the effect of superplasticizer and its components on the structure and phase composition of cement stone.

Briefly, chemical admixtures are those ingredients in concrete other than hydraulic cement, supplementary cementitious materials (SCMs), water, aggregates, and fiber reinforcement that are added to the mixture immediately before or during mixing. The development of ideas concerning the mechanism of additives, are inextricably linked with the progress in the theory of hydration and hardening of mineral binders. Also, studies related to the rational economy of heat treatment of reinforced concrete structures are very relevant, but they require an optimal class of the additive with its optimization with a mineral binder. The effectiveness

of an admixture depends upon factors such as its composition, addition rate, time of addition; type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete.

By aggressive environments, we take into consideration those environments in which corrosion of a constructional materials occur. According to its aggregate state, aggressive media can be gaseous, liquid or solid, and in many cases multiphasic. On the basis of modern representation of the physical-chemical phenomena and surface contact interactions theory, we can change, in the desired direction, the properties of cement paste, concrete mix and the concrete itself by introducing specific additives (modifiers) into the cement systems.

Materials and Methods of Research. The study was conducted on fine-grained concrete using the mathematical planning of an experiment using the software Statistica 10, Inc. As a modifying agent, an additive superplasticizer (SP) was used, which was brought from Turkmenistan. The composition of fine-grained concrete varied three main factors. In the experiment vary: the amount of the binding part of the concrete; the content of the filler and the amount of additive – superplasticizer. Factor values are given in natural form. The main level of factors, the interval of variation, and the names of the factors (Table 1).

Table 1

Coded variable	**Variation interval**			
	Code value	Value factors		
		X_1 (knitting)	X_2 (additive)	X_3 (filler)
Main level	0	0,5	0,01	0,5
Variation interval	ΔX_i	0,5	0,01	0,5
Upper level	+	1	0,02	1
Lower level	–	0	0	0

The construction of functional models of experimental dependencies of concrete properties on its composition includes the following steps:

- refinement, depending on the specific task, of the parameters to be optimized (concrete strength, workability of the concrete mix, etc.);
- selection of factors determining the variability of the parameters to be optimized;
- determination of the basic initial composition of the concrete mix;
- choice of intervals of variation of factors;
- selection of the plan and conditions of the experiment;
- processing of the results of the experiment with the construction of mathematical models of dependencies of the properties of the concrete mix and concrete on the selected factors.

According to the plan of the experiment is calculated 15 experiments on the test in each. Output parameters, name of output parameter and number of measurements (Table 2).

Table 2

№ of experience	Planning matrix			Natural values of variables			Output parameter		
	X_1	X_2	X_3	X_1	X_2	X_3	Y_1	Y_2	*Ya*
1	1	–1	–1	1	0	0	91,1	89,9	91,1
2	–1	1	–1	0	0,02	0	80,6	78,2	80,6
3	–1	–1	1	0	0	1	50	52,6	50
4	1	1	1	1	0,02	1	36	40,6	36
5	1	–1	1	1	0	1	32,85	34,4	32,85
6	–1	1	1	0	0,02	1	61,85	54,1	61,85
7	1	1	–1	1	0,02	0	95,9	93,1	95,9
8	–1	–1	–1	0	0	0	85,95	91,5	85,95
9	1	0	0	1	0,01	0,5	50,55	44	50,55
10	–1	0	0	0	0,01	0,5	53,35	49,7	53,35
11	0	1	0	0,5	0,02	0,5	29,7	22,1	29,7
12	0	–1	0	0,5	0	0,5	48,65	58	48,65
13	0	0	1	0,5	0,01	1	40,65	37	40,65
14	0	0	–1	0,5	0,01	0	92,25	98,8	92,25
15	0	0	0	0,5	0,01	0,5	43,73	43,3	43,7

After automatic verification of the entered data, the program calculates the coefficients of the mathematical model (Table 3) and displays the coefficients of the equation (Table 4).

Table 3

№ of experience	X_1	X_2	X_3	X_{11}	X_{22}	X_{33}	X_1X_2	X_1X_3	X_2X_3	Yi.s
1	91,1	–91,1	–91,1	91,1	91,1	91,1	–91,1	–91,1	91,1	91,1
2	–80,6	80,6	–80,6	80,6	80,6	80,6	–80,6	80,6	–80,6	80,6
3	–50	–50	50	50	50	50	50	–50	–50	50
4	36	36	36	36	36	36	36	36	36	36
5	32,85	–32,85	32,85	32,85	32,85	32,85	–32,85	32,85	–32,85	32,85
6	–61,85	61,85	61,85	61,85	61,85	61,85	–61,85	–61,85	61,85	61,85
7	95,9	95,9	–95,9	95,9	95,9	95,9	95,9	–95,9	–95,9	95,9
8	–85,95	–85,95	–85,95	85,95	85,95	85,95	85,95	85,95	85,95	85,95
9	50,55	0	0	50,55	0	0	0	0	0	50,55
10	–53,55	0	0	53,55	0	0	0	0	0	53,35
11	0	29,7	0	0	29,7	0	0	0	0	29,7
12	0	–48,65	0	0	48,65	0	0	0	0	48,65
13	0	0	40,65	0	0	40,65	0	0	0	40,65
14	0	0	–92,25	0	0	92,25	0	0	0	92,25
15	0	0	0	0	0	0	0	0	0	43,73
sum	–25,35	–4,5	–224,45	638,15	612,6	667,15	1,45	–63,45	15,55	893,13

Table 4

b_1	b_2	b_3	b_{11}	b_{22}	b_{33}	b_{12}	b_{13}	b_{23}	b_0
–2,54	–0,45	–22,45	13,01	0,23	27,51	0,18	–7,93	1,94	28,51

The results of the fitness test are shown (Table 5).

Table 5

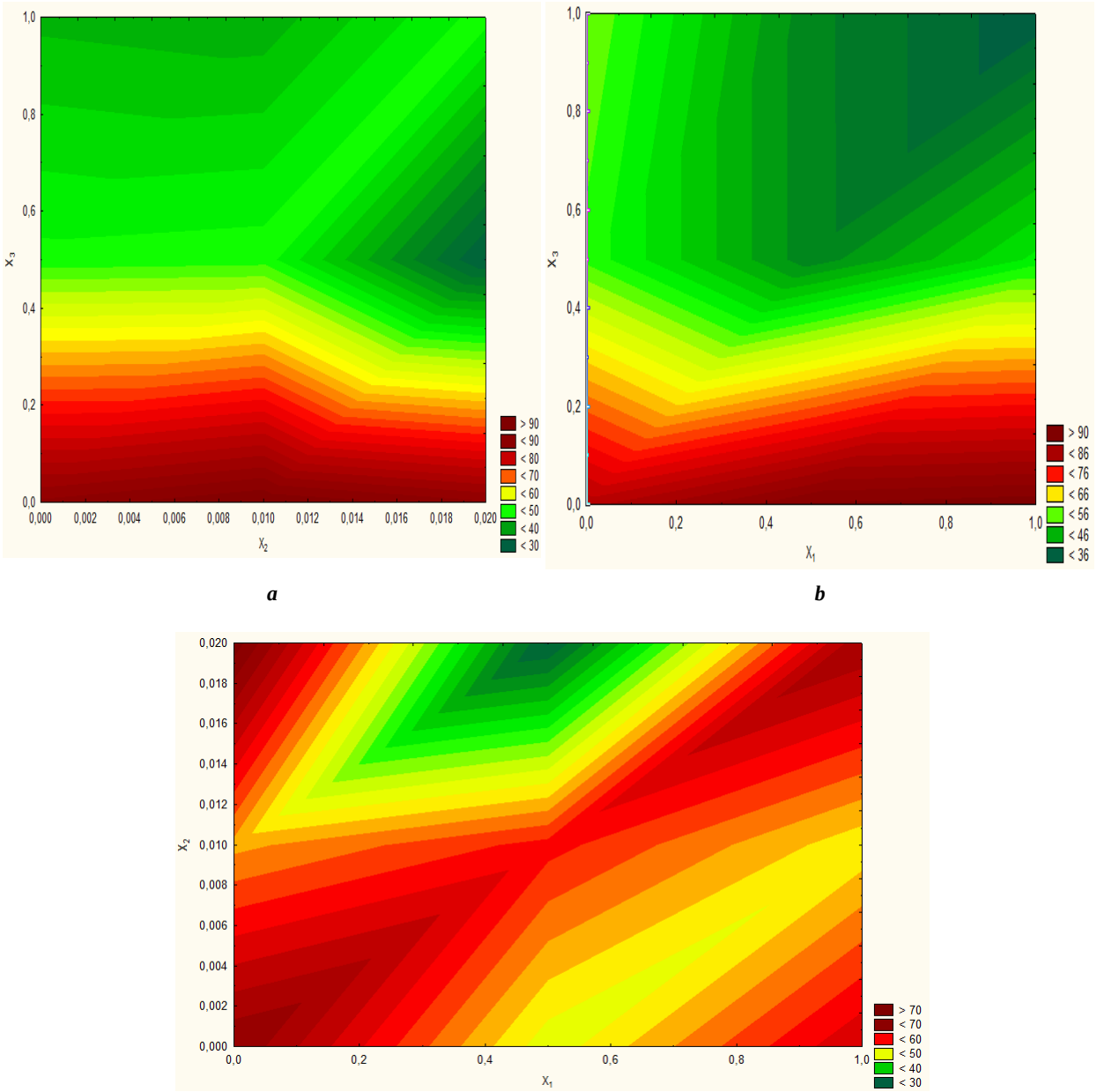
№ of experience	Results		Yn-Yp	$(Yn-Yp)^2$
	Experienced Yn	Calculated Yp		
1	91,1	99,31	–8,21	9,9225
2	80,6	83,75	–3,15	35,6409
3	50	55,97	–5,97	4,0401
4	36	38,01	–2,01	3,3124
5	32,85	34,67	–1,82	10,6276
6	61,85	58,59	3,26	1,02
7	95,9	94,89	1,01	8,6436
8	85,95	88,89	–2,94	133,8649
9	50,55	38,98	11,57	86,3041
10	53,35	44,06	9,29	1,988
11	29,7	28,29	1,41	378,6916
12	48,65	29,19	19,46	50,1263
13	40,65	33,57	7,08	189,8884
14	92,25	78,47	13,78	231,6484
15	43,73	28,51	15,22	9,9225

A mathematical model of the strength of concrete is recognized as adequate by the Fisher criterion and is applicable for solving recipe-technological problems.

The following polynomial models for the studied characteristics were finally obtained:

$$Yi.s = 27,5 + 0,3 \cdot X_1 - 4,1 \cdot X_2 - 25,3 \cdot X_3 + 10,6 \cdot X_1^2 - 2,1 \cdot X_2^2 + 25,1 \cdot X_3^2 - 4,4 \cdot X_1 \cdot X_2 - 11,5 \cdot X_1 \cdot X_3 + 6,5 \cdot X_2 \cdot X_3. \quad (1)$$

Using the obtained equation (1), we made additional constructions, built a graph of projections in a two-dimensional coordinate system, allowing to analyze the change in the output parameter depending on one variable factor (Figure 1).



a ***b***

c

a **– X_1 = const; *b* – X_2 = const; *c* – X_3 = const**

Figure 1. – Projection chart

Samples with the highest bending strength were used as standards for the subsequent optimization of the concrete composition. By constructing projection graphs, we obtained the following optimization parameters:

1) Cement content: 0,4;
2) Plasticizer input: 0,08;
3) Sand content: 0,02.

One of the most effective ways to increase the durability of concrete and reinforced concrete structures to the impact of the environment, is to control the structure of concrete during the period of its formation, which is achieved by adding surfactants, in particular organ-silicon compounds of various types to the concrete mixture. Silicone compounds, used as additives to concrete, release some amount of gas (hydrogen) into the concrete mixture upon their contact with an alkaline medium or to have an air-entraining effect. Air-entrainment dramatically improves the durability of concrete exposed to cycles of freezing and thawing and deicer chemicals. In addition, the additives hydrophobize the walls of pores and capillaries, which leads to a decrease in the adhesion of ice and salt crystals to them in the case of simultaneous action of salt solutions and freezing. At the same time, the capillary suction of liquid into concrete is also excluded or significantly reduced.

We make observations and fix the change in the mixture, with respect to the change in the composition and amount of the admixture. Based on the technical requirements, such a solution did not present an opportunity to put into the pipe, since it was dry (Figures 2–4).

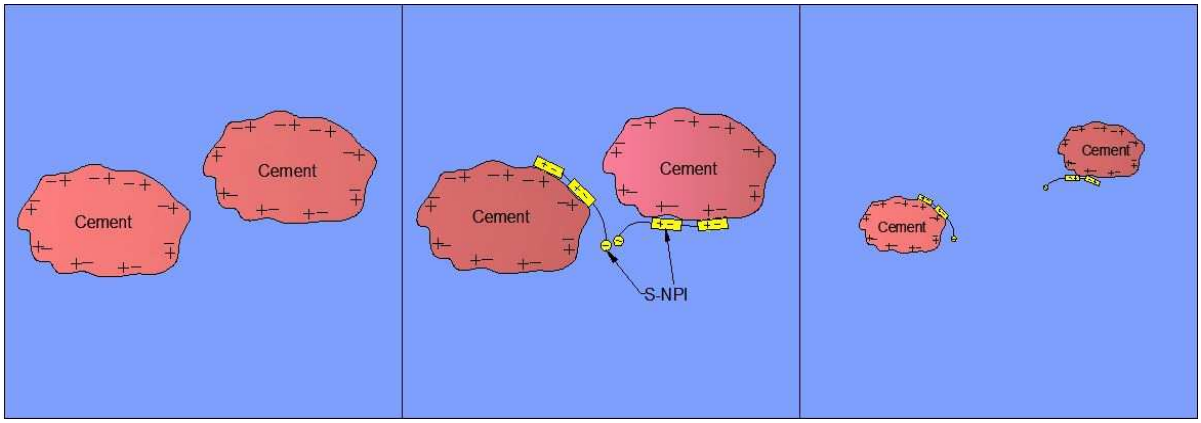


Figure 2. – Mechanism of dispersive action of water-reducing admixtures

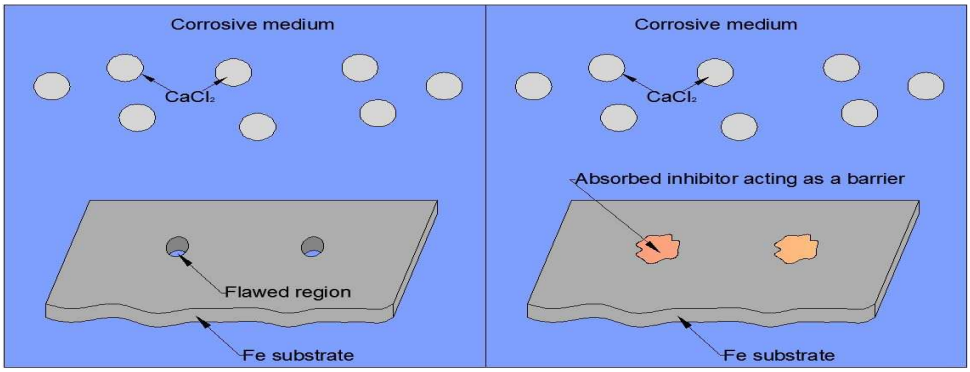


Figure 3. – Mechanism of corrosive inhibitors

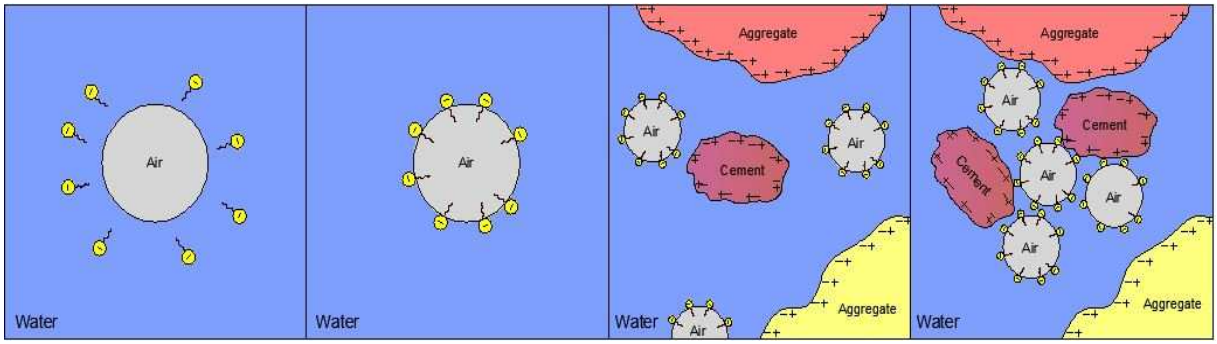


Figure 4. – Mechanism of air-entrainment

Conclusion. An experiment was conducted based on the results:

- It was determined that the optimal content of the superplasticizer has a positive effect on the strength and corrosion resistance of the cement stone;

- The use of superplasticizer reduces the water-cement ratio, has a great effect on increasing the mobility of the concrete mix and significantly increases the strength of concrete in compression, as well as on bending.

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ВЛИЯНИЕ СУПЕРПЛАСТИКАТОРОВ НА СТРУКТУРООБРАЗОВАНИЕ ЦЕМЕНТНОГО КАМНЯ В СОЛЯНОЙ СРЕДЕ

канд. техн. наук, доц. Д.Н. ШАБАНОВ; И. ИЛЬМУРАДОВ; С. МАТНИЯЗОВ
(Полоцкий государственный университет)

Рассмотрены вопросы улучшения эксплуатационных характеристик бетона путем добавления суперпластификатора в структуру цементного камня. Показано влияние суперпластификатора на формирование структуры цементного теста, прочность на изгиб, а также на коррозионную стойкость. Описано общее состояние проблемы защиты железобетонных элементов от агрессивного внешнего воздействия. На основе полученных полиномиальных моделей построена поверхность отклика. Добавление химических добавок различного назначения рассматривается как один из наиболее важных способов повышения производительности в строительстве.

Ключевые слова: *цемент, соль, добавки, коррозия, суперпластификатор, поверхность отклика.*