UDC 691.162

PHYSICAL-MECHANICAL AND STRUCTURE-FORMING PARAMETERS OF CONCRETE

JAMAL FARRAN, DMITRY SHABANOV
Polotsk State University, Belarus

This article describes a three-factor experiment, inscribing three different additives improving the characteristics of concrete and reinforced concrete. The experiments explain the physical and mechanical properties of concrete, the mechanism of action of chemical admixtures resisting the corrosive influence on structures, the kinetics of corrosion, and the structure-forming parameters when using each of the additives. The experiments also show the performance of the admixtures on the mobility and workability of the concrete mixture. Conclusions are drawn, that each of the three additives acts differently on the structural formation of concrete.

Introduction. 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

Task formulation. The study of various chemical admixtures and their effect on concrete.

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, is 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 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.

The superplasticizer S-NPI, hydrophobizer GKJ-10, and carboxymethylcellulose CMC were used as the main additives improving the corrosion resistance, as well as strength and mobility.

Studies were carried out on fine-grained concrete of composition 1:3. As well as, portand cement M:300 and sand M_s – 2,1. The testing of the beams 40 × 40 × 160 cm, was carried out according to the GOST-310.4-8 for determining the bending strength, they were studied on the MII-100 installation, on the hydraulic press PSY-125 for determining the compressive strength, and also for the corrosion resistance according to the methods approved by NIIJB, based on the exploitation conditions of the studied structures. In quantitative terms, the admixtures from the weight of the cement in (%) were:

1) S-NPI: 0.3-1.0%;
2) CMC: 0.5-1.0 %;
3) GKJ-10: 0.2%.

All additives were introduced with the medium dissolved after preparation of dry cement-sand mixtures. The sample where put in a normally humid medium.

The tests computing the increase of strength, were characterized by the two additives S-NPI and CMC. The results showed that S-NPI increased the strength:

- Compression: 1.7 times;
- Bending: 1.4 times;

and that CMC also increased the strength:

- Compression: 1.1 times;
- Bending: 0.8 times.

In the case of achieving the maximum mobility, the ultimate strength is maintained when using S-NPI by 60%, and by 40% when using CMC, from the initial state of the concrete beam.

When determining the corrosion resistance, the samples were placed in a $CaCl_2$ solution (calcium chloride), of concentration 30 grams of salt per 100 ml of water at a temperature of 50°c. Intermediate tests of the samples were carried out after 7 days.

The results of the weight loss of all samples did not exceed 3%, the loss of strength when using CMC was 5%, and with the admixture S-NPI was 2%.

Table 1. – Strength measurement at different times in different mediums

№	Code	S-NPI	GKJ-10	CMC	Measurement	28 days		3 months in water		2 months in salt		2 months in water		5 months		4 months in salt		4 months in water	
		X_1	X_2	X_3	Y_1^1	C	B	C	B	C	B	C	B	$\bar{S}_c^2$	$\bar{Y}_b^2$	C	B	C	B
1	a	1	0	0	2.2	460	54.6	384	57.2	421	114	409	66.5	326	73	364	77.5	400	44.8
2	b	0	0.02	0	2.2	324	44.7	292	37	297	72.6	323	39.9	258	32.9	200	62.7	302	44.6
3	c	0	0	1	3	248	33.4	169	30.9	192	40	221	41.6	156	41	155	43.1	138	38.6
4	abc	1	0.02	1	3	192	30.2	166	34.3	138	21	163	28.1	168	28.2	136	36.3	105	24.3
5	ac	1	0	1	2.8	162	25.5	116	23.9	80	22.85	93	14.6	104	12.8	73	30.7	71	21.3
6	bc	0	0.02	1	2.9	228	32.6	226	35.2	188	51.9	187	31.9	190	39.9	143	48.4	105	27.8
7	ab	1	0.02	0	2	456	48.1	377	44.4	370	51.9	308	49.4	306	37.9	203	57.7	358	46.9
8	-1	0	0	0	2.3	340	41.1	139	44.4	325	75.9	300	49.6	302	35.6	273	61.8	354	48.2
9	2a	1	0.01	0.5	2.9	200	26.8	152	29.4	186	50.6	163	324	169	29.6	91	31.6	153	25.8
10	(-2a)	0	0.01	0.5	2.8	224	31.3	209	35.7	117	53.4	178	30.1	184	33.4	137	39.6	151	34.5
11	2b	0.5	0.02	0.5	2.6	168	23.7	199	31.1	107	19.7	164	38.2	120	25.9	95	31	135	34.8
12	(-2b)	0.5	0	0.5	2.8	288	33.4	236	40	235	38.7	213	40.1	184	34.9	132	42.4	156	39.6
13	2c	0.5	0.01	1	3	218	37.5	208	35.7	163	30.7	203	35.5	136	28.5	108	34.1	193	36.2
14	(-2c)	0.5	0.01	0	2.3	314	34.2	332	46.4	385	81.3	296	45.5	242	415	161	71.4	260	53.2
15	0	0.5	0.01	0.5	3	212	20	184	30.6	195	33.7	150	35.2	213	37.2	101	35.1	140	36.5

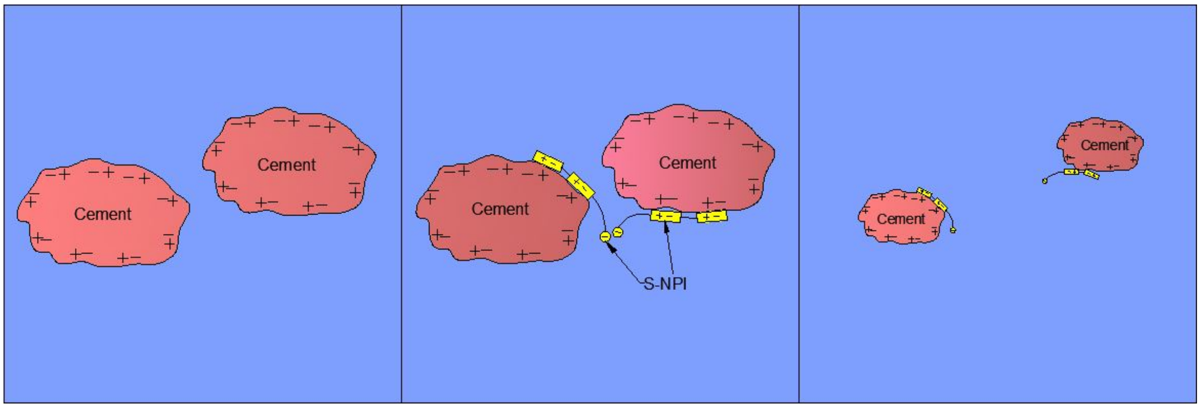


Fig.1. Mechanism of dispersive action of water-reducing admixtures

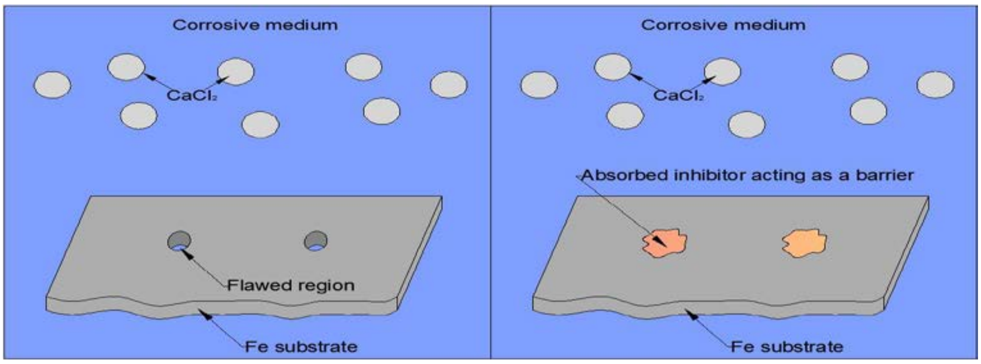


Fig.2. Mechanism of corrosive inhibitors

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. Therefore, in order to have a comfortable application, we applied the S-NPI additive, which improves the state of the cement-sand mortar.

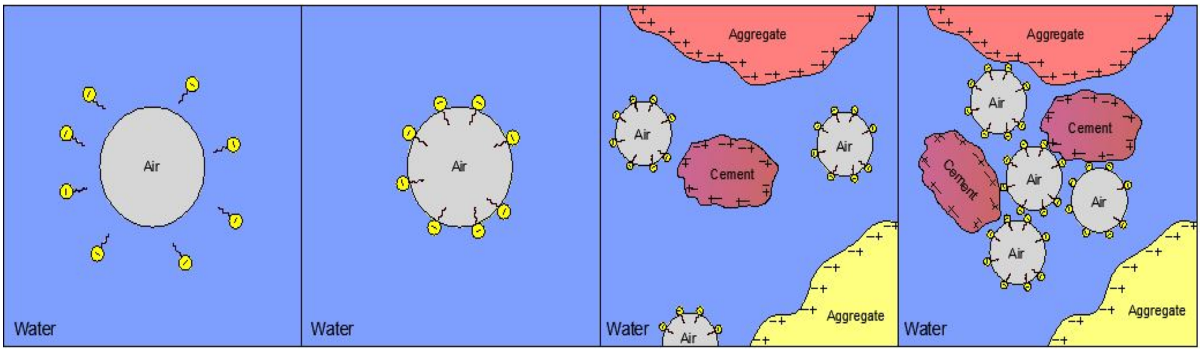
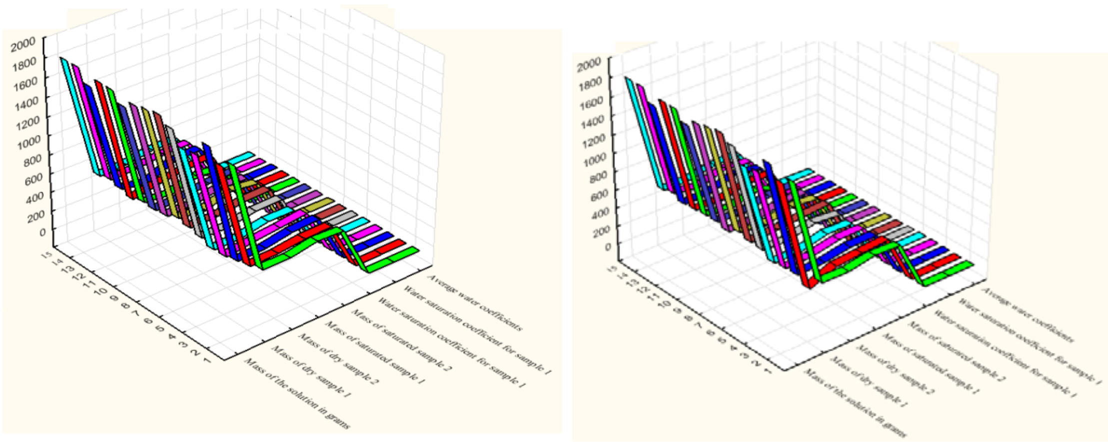


Fig. 3. Mechanism of air-entrainment



a) b)

Fig. 4. Variation of water saturation based on the medium: a) water; b) salty medium

Table 2. – The variation in water saturation based on the medium

Mass of the solution in grams			1750	1680	1700	1600	1600	1675	1750	1750	1700	1650	1750	1650	1625	1750	1750
			1660	1580	1800	1590	1590	1750	1800	1750	1750	1650	1750	1850	1675	1800	1800
Average mass			1705	1630	1750	1595	1595	1712.5	1775	1750	1725	1650	1750	1750	1650	1775	1775
Water medium	Mass of dry samples	1	545	500	475	440	435	480	515	533	480	470	475	465	470	500	465
		2	545	510	490	480	435	480	512	500	485	475	450	490	425	505	470
	Mass of saturated samples	1	600	545	535	500	495	530	555	595	540	520	520	520	540	540	515
		2	580	550	550	535	495	530	560	555	535	530	500	550	555	550	520
	Water saturation coefficients	1	10.09	9	12.63	13.63	13.79	10.41	7.77	11.63	12.5	10.63	9.47	11.82	14.8	8	10.75
		2	6.42	7.84	12.24	11.45	13.79	10.41	9.38	11	10.3	11.1	11.1	12.24	12.24	8.91	10.64
		average	8.225	8.42	12.44	12.54	13.79	10.41	8.58	11.32	11.4	10.87	10.29	12.03	13.52	8.46	10.7
Salty medium	Mass of dry samples	1	555	505	475	465	445	505	510	540	475	505	500	490	480	520	485
		2	550	525	490	480	445	495	530	510	480	490	475	485	485	485	485
	Mass of saturated samples	1	595	540	530	530	515	565	560	590	540	555	550	545	575	570	540
		2	580	565	540	540	515	540	580	565	550	555	535	545	535	540	550
	Water saturation coefficients	1	7.2	6.93	11.57	13.9	15.7	11.88	9.8	9.25	13.68	9.9	10	11.22	13.54	9.61	11.34
		2	5.45	7.62	10.2	12.5	15.7	9.09	9.43	10.78	14.58	13.26	12.63	12.37	10.3	11.34	13.4
		average	6.31	7.28	10.89	13.2	15.7	10.49	9.62	10.02	14.13	11.58	11.32	11.8	11.92	10.48	12.37
The required amount of media shutter for slumping the cone by 107 mm			18 kgs. of the mixtures														
			2200 ml	2200 ml	3000 ml	3000 ml	2800 ml	2900 ml	2000 ml	2300 ml	2900 ml	2800 ml	2600 ml	2800 ml	3000 ml	2300 ml	3000 ml

Based on observations, we deduced several results:

- The first composition was the control mixture. We took 500g of sand of brand 1500g for the fraction, and according to the spread of the cone (105 < 107 < 110), the required amount of water (275 g) was determined. After mixing, the solution was placed in a mold and vibrated.
- The second composition – is the composition in which we applied the admixture CMC – 0.5-1% mass of the cement. The CMC was dissolved in water so that the resulting emulsion did not exceed 275 g. Emulsion – adhesive liquid. After mixing, the solution turned out to be dry. On the shaking pad, the cone slumped by 101mm, and the upper part of the cone collapsed.

The solution was placed in a mold and vibrated on a vibrating pad (T.V. = 3.45 min) until the appearance of cement milk.

At 1% the cone remained unchanged 100mm, and all of it almost collapsed after 30 impacts on the shaking pad. The solution was placed in a mold and was vibrated for 3 minutes on the shaking table until the appearance of the cement milk.

- The third composition is the composition which was supplemented with GKJ-10 - 2.5ml of GKJ-10 dissolved in water. With the introduction of the admixture into the water, no visual changes occurred except for a change in the color, under the color of the admixture (light brown). After mixing, the solution was placed on a shaking pad. The solution increased its mobility, which is evident from the slumping of the cone by 107mm. The solution was then placed in a mold and was vibrated for 2.5 minutes.
- In the fourth composition, we decided to combine CMC and GKJ-10 leaving *W/C* = constant and W = 275mm. After mixing, the solution was placed on the shaking pad. After 30 impacts, the cone slumped by 105mm, which is 2mm less than the third composition. The appearance of cement milk happened after 2.15 minutes.

After those studies, we can make several conclusions:

1. The usage of S-NPI decreases the water-cement ratio, has a great effect in increasing the mobility of the concrete mixture, and vastly increases the strength of concrete for compression, as well as for bending.
2. The usage of CMC helps in obtaining a better concrete in case of mobility, with the preservation of the concrete strength. Also the usage of CMC increases the corrosion inhibition of the concrete mixture.
3. The usage of GKJ-10 helps preserve the durability of concrete by a large factor.
4. The usage of complex mixture, in our case CMC and GKJ-10, helps maintain the durability of concrete with the preservation of corrosion inhibiting.

REFERENCES

1. Кондрашов, Г.М. Коррозионная стойкость бетонов, модифицированных латексами винилового ряда / Г.М. Кондрашов // Бетон и железобетон. – 2006. – № 5. – С. 22–25.
2. Калмыков, Л.Ф. Эффективные добавки на основе отходов химических и нефтехимических производств белоруссии для бетонов и растворов / Л.Ф. Калмыков. – 47 с.
3. Юхневский, П.И. О механизмне пластификации цементных композиций добавками / П.И. Юхневский // Строительная наука и техника. – 2010. – С. 64–69.
4. Рекомендации по применению суперпластификатора С-НПИ в тяжелом бетоне. – 1987. – С. 1–52.
5. Kosmatka, Steven, H. / Design and Control of Concrete Mixtures / Steven, H. Kosmatka, Wilson Michelle L. – 459 p.