Influence of various additives on properties of concrete

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Abstract. A comparative analysis of concrete samples without chemical additives and three concrete samples with additives was carried out. The first sample contains the liquid additive, the other two contain the powder additive. The article aims at finding out the effectiveness of additives influence on the physical and mechanical properties of concrete and the basis for the application areas of modified types of concrete. By means of laboratory tests, the physical and mechanical properties of concrete mixtures are determined. To determine the strength characteristics of concrete samples, the IM-1250M testing machine was used. The tests were carried out under the same temperature and humidity conditions. According to the results of the experiments, the samples with the multifunctional additive "D-5" showed the best characteristics of concrete, and the samples with the dolomite flour additive were the cheapest. As a result of the experimental analysis, the effects of three additives on the strength characteristics of concrete and water resistance were determined. Cemplast and D-5 additives are highly effective modifiers of concrete and mortar. They can increase the strength by 20-40% at the age of 28 days at dosages of 1.6-6% with a decrease in water-cement ratio and a decrease of cement amount by 20%. Additives highly increase the workability of the mixture, air entrainment and water resistance. While using the chemical additives an early set of the concrete design strength is observed for the construction time reducing in 7 days.

1 Introduction

Modern construction and architecture are inseparably connected with reinforced concrete. Only in the 20s of the XX century reinforced concrete which had been invented in the middle of the XIX century received that significance in construction that drew it out on first place in the supporting and enclosing structures.

The widespread use of reinforced concrete structures is explained by the numerous advantages of reinforced concrete - increased strength, durability, compressive strength, good resistance to weathering. The plasticity of concrete in the wet state makes it easy to manufacture products of various shapes, and the reinforcement gives it tensile strength, which concrete does not have [1]. One of the main tasks of capital residential and industrial construction is the increasing efficiency of the production. To accomplish this task, it is

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required to increase the quality of design solutions for reinforced concrete structures, to manufacture higher quality concrete and to reduce the construction costs. In the last decades the problems of the quality improvement, durability, concrete and reinforced concrete cost-effectiveness in construction have been successfully solved by the industry chemicalization, in particular, through the usage of various organic and inorganic compounds as special concrete additives. They essentially influence on the hardening processes, added in small quantities relative to the mass of cement, the structure of cement stone and concrete, provide an improvement in the whole set of physical and technical properties of concrete - strength, density, water resistance, frost resistance, corrosion resistance, etc. [2 and 3].

The research questions of additives efficiency on the structure formation processes, the durability of high and high strength cement concrete have not lost their actuality in spite of the fact that there are significant successes in some chemical additives expansion, first of all, superplasticizers, the expansion of their production and usage. There are also no estimates and generalizations in scientific literature which concern to the rational areas of modified concrete application with various chemical additives. In this regard, all these issues remain relevant and need to be better studied including the efficiency assessment questions of the high-strength concrete usage based on superplasticizers and organomineral modifiers in prefabricated and monolithic construction [4].

2 Methods and materials

The preliminary composition of the concrete mix was selected. The selection of the heavy (ordinary) concrete composition consists of the establishing the most rational correlation between the materials of the concrete (cement, water, sand, gravel). This ratio should provide the required workability of the concrete mixture for the accepted compaction method, as well as the acquisition of the specified strength of the concrete with the lowest cement consumption at the appointed time

The design procedure for the concrete composition was carried out according to the well-known methods in accordance with GOST 27006-86 "Concretes. Rules for the composition selection" and Recommendations for the composition of heavy and fine-grained concrete selection (to GOST 27006-86). The concrete B25 M350 was selected with an average design strength of 327.4 kgf / cm² for the design class of concrete.

While conducting the experimental research the main source components for concrete were used:

- Portland cement PC 500 (Voronezh branch of Eurocement Group JSC;
- Crushed stone of fractions of 5-20 mm was used as a large aggregate (Ltd PROGRESS RNO-Alania);
- sand with a fineness modulus $M_k = 2.8$ (Ltd PROGRESS RNO-Alania) was used as a fine aggregate.

To confirm the compliance of the declared brand of cement with the specified manufacturer, the activity of cement was determined in the following order:

1. According to GOST 30744-2001, the normal density of the cement paste (31%) was determined using a Vika device.

2. 3 beam samples of 160 × 40 × 40 mm size were made (GOST 310.5-88 "Cements. Test methods") with subsequent determination of bending and compression strength, and the cement activity was determined using the accelerated method on its contract on the Cement-Forecast device, equal to $R_{28} = 51$ MPa. After 28 days, the samples of the beam stored in water were tested for bending and compression. The average strength value $R_{28} = 49.4$ MPa of six samples corresponds to cement grade 500 [4 and 5].

The prescribed concrete brand M350 (class B25). In this case, the composition of concrete: cement - 380 kg, sand - 780 kg, crushed stone - 1100 kg, water - 160 l.

The concrete forms with dimensions of 10x10x10 cm were used for the laboratory tests.

Table 1. The composition of concrete mixtures for experiments.

Concrete type	cement	sand	grave	water	additive
simple	1.52	3.12	4.4	0.640	
withdolomite flour	1.216	3.12	4.4	0.510	0.484
withD - 5	1.216	3.12	4.4	0.510	0.046
withCemplast	1.216	3.12	4.4	0.510	0.046

They replaced the concrete mix for each composition and lay in layers in a mold with compaction and vibration (fig.1.) [6, 7]

Fig. 1. The compaction of the concrete mix.

Figure 2 shows the ready concrete samples after vibration.

Fig. 2. Ready concrete samples after vibration.

The moment of the concrete sample destruction on a testing machine is shown on Figure 3

Fig. 3. The moment of the concrete sample destruction.

3 Results of research

Tables 2, 3 shows the determination of the concrete samples strength.

Table 2. The compression test results of concrete samples (on the 7th day).

Concrete type	Sizes			Weight g.	density g/cm ³	Destructive loadtf.	Strength kgs/cm ²	Average strength kgs/cm ²
	L	W	H					
simple	10	10	10	2462	2.462	22.40	212.8	212.325
	10	10	10	2470	2.470	22.30	211.85	
withdolomite flour	10	0	10	2426	2.426	29.90	284.05	269.99
	10	10	10	2412	2.412	26.94	255.93	
with «D-5»	10	10	10	2476	2.476	32.75	311.25	301.88
	10	10	10	2496	2.496	30.79	292.505	
with «Cemplast»	10	10	10	2324	2.324	21.95	208.525	211.97
	10	10	10	2320	2.320	22.675	215.41	

Table 3. The compression test results of the samples (on the 28th day).

Concrete type	Sizes			Weight g.	Density g/cm ³	Destructive load tf.	Strength kgs/cm ²	Average strength kgs/cm ²	Concrete class
	L	W	H						
simple	10	10	10	2462	2.462	34.82	330.8	333.0	C25
	10	10	10	2470	2.470	35.28	335.2		
With dolomite flour	10	10	10	2426	2.426	36.84	349.98	350,84	C25
	10	10	10	2412	2.412	37.02	351.69		
with «D-5»	10	10	10	2476	2.476	42.98	408.31	406.17	C30
	10	10	10	2496	2.496	42.53	404.035		
with«Cemplast»	10	10	10	2324	2.324	34.31	325.94	328.0	C25
	10	10	10	2320	2.320	34.74	330.06		

Figure 4 shows a graph of the additives effect on the concrete strength.

Fig. 4. Graph of the additives effect on the concrete strength.

According to GOST 12730.5-84 “Concretes. Methods of water resistance determination” the water resistance of the samples by the accelerated method of its breathability was determined. 6 cubes with 150 mm ribs of control concrete and concrete with additives were made to determine the water resistance.. The tests were carried out with the help of an “Agama” type device and a VIP permeability measurer 1.3.

Figure 5 shows a device schematic diagram which determines the air permeability of the concrete surface layers.

Fig. 5. Schematic diagram of a device for determining the air permeability of the concrete surface layers (1 concretesample; 2-camera device; 3-camera flange; 4 - vacuumgauge; 5 - vacuum pump; 6 - sealingmastic; 7 – valve).

The principle of the devices operation is based on determining the time of the vacuum pressure drop previously created in the vacuum chamber of the device, the cavity of which has airtight contact through the mastic with the surface of the test material. The pressure drop in the chamber is due to the filtration of ambient air into it through the pores and defects of the material. The rate of pressure change depends on the parameter of the material breathability or the inverse value of the material resistance to air penetration. Physical – mechanical properties of concrete are pointed in the table 4.

Table 4. Physical – mechanical properties of concrete.

Concrete breathability parameter,sm/s	Concrete resistance to air penetration, s/sm	Concrete brand to water resistance
0.325-0.224	3.1-4.5	2
0.223-0.154	4.6-6.5	4
0.153-0.106	6.6-9.4	6
0.105-0.0728	9.5-13.7	8
0.0727-0.0510	13.8-19.6	10
0.0509-0.0345	19.7-29	12
0.0344-0.0238	29.1-42.0	14
0.0237-0.0164	42.1-60.9	16
0.0163-0.0113	61-88.5	18
0.0112-0.0077	88.6-130.2	20

During the test, the sealing mastic bundle with a diameter of at least 6 mm is laid on the chamber flange along its midline and the ends are connected. The test surface is cleaned from the cement paste film with a wire brush. The chamber is mounted with a flange on the lower (according to the molding conditions) surface of the sample and a vacuum of 0.7 kg / cm2 is created in the chamber cavity. Further, the stopwatch determines the time of pressure drop to 0.65 kg / cm2. The obtained rates of the pressure drop time are recorded in the order of their increase and the arithmetic mean value of two average samples (third and fourth) is determined as a parameter characterizing the air permeability of concrete in the series.

Figure 6 shows water resistance grades of concrete samples

Fig. 6. Water resistance grades of concrete samples. Where: W8 – simple concrete, W16 – samples with Cemplast, W18 – with dolomite flour, W20 – with additive D-5.

4 Conclusion

The appropriate and purposeful usage of the concrete additives allows the engineers of concrete plants to modify fresh and solid concrete properties according to different aims of the construction industry. At the same time, it allows to realize the highly- qualified and durable concrete production in various climate conditions [8]. The most important quality of concrete construction will be its high quality and durability in future. From this site the additives usage in concrete is necessary and this method has become the integral part of all concrete technologies [9].

The application of additive should be economically worthwhile it cannot allow the increase of concrete cost.

As a result of the experimental analysis the influence of additives on concrete durability characteristics and water resistance was determined.

Additives Cemplast and D-5 and dolomite flour are high- effective modifications of concrete and construction solutions [10]. They can increase strength by 20-40% at the age of 28 days at dosages of 1.6-6% with a decrease in water-cement ratio and a decrease in the amount of cement by 20%. Additives greatly increase mixture workability, frost resistance, air entrainment, water resistance [11]. While using chemical additives it is observed an early set of design concrete strength on the 7th day that leads to the reduction of construction period [12 and 13].

It is appropriate to use dolomite flour and D-5 in constructions which have complex requirements on strength, water and frost resistance.

Considering a relatively high cost of Cemplast and not high rates of strength and water resistance the application of this additive can be justified only in concrete which has high strength requirements [14 and 15].

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