Modification of concrete with superplasticizers

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Abstract The use of a chemical additive (superplasticizer) is the most universal and accessible means of managing concrete technology, regulating properties, and saving cement. A chemical additive, which is introdu-ced into concrete in small quantities (0.1...2.0% of the cement mass), changes the properties of the concrete mixture and concrete in the desired direction.

Keywords

Concrete, admixture, superplasticizer, cone setting, water-holding capacity, strength, water-cement ratio, technology.

Fig. 1. Composition of concrete prepared in the first experiment

Introduction

In recent years, the composition and technology of effective chemical additives have been developed, which have a significant plasticizing effect (superplasticizer). When using this additive, the workability of the concrete mixture increases, the water requirement decreases, the strength of the concrete increases, the obtaining of a thin, plastic concrete mixture allows us to use the molding technology of laying, dramatically reduce the labor intensity, due to good ease of placement, the vibration time and heat treatment mode are sharply reduced. Plastic concrete mixture is easy to transport, pump and store. The molded concrete mixture does not crumble and retains its bond.

Main part

The superplasticizer was first used in the world in Germany and Japan. Currently, it is used in all developed countries. It is effective in thin-walled, densely reinforced, complex-configuration structures. In monolithic structures, concreting should be carried out by adding a plastic mixture.

However, when using a superplasticizer, it is important to take into account the duration of the liquefying effect, which varies within 1...1.5 hours. Therefore, the plasticizer is added to the readymade mixture. Before transporting the mixture, the amount of plasticizer is calculated at the factory, which is converted into the volume of the concrete truck. The plasticizer is added to the concrete mixture immediately before unloading. The concrete mixture is completely mixed with the plasticizer within 5 minutes. The plasticizer is stored in a closed container. Many of them need to be protected from sunlight and frost.

How does a superplasticizer "work"? It consists of watersoluble polymer molecules. When mixed with concrete, these molecules adhere to the surface of the cement grains and help create an ionic group. As a result, part of the cement becomes negatively charged, which causes mutual repulsion and hysteretic hindrance (restriction of intra or inter-molecular interactions caused by the spatial structure of the molecules).

Superplasticizers can be divided into four different groups: melamine formaldehyde sulfide condensate (SMF); naphthalene formaldehyde sulfide condensate (SNF); modified lignosulfonate (MLS), sulfuric acid ester, polyacrylate, polytyrol sulfonate, etc.

The most effective superplasticizers are:

Superplasticizers derived from modified lingosulfonate: Acosal fluid and NT, Ozsan S, VN liguidaat WS, Botokem LP, Plastiment BV40, Pozzolitr 300N, Pozzolitr8 and others.

Sulfidated melamine formaldehyde water-soluble superplasticizer Melment L10 and F10, Complast M1, Sealoplaz super and others.

Sulfidated naphthalene formaldehyde water-soluble superplasticizer: Agilplast, Cozmix Spi, Blankol N, Tamol N, Lomaz D, Rheobild, Crysofluid and others.

Let's give data on several superplasticizers: BEVETOL-RDG type, used for slow-setting concrete. (ASTMC-494; Type A, D and G, ELOTEN934-2; T 11.1 and T11.2). Color dark brown, dosage 0.2…0.8% (of cement mass)

BEVETOL-SPL G type, used for slow-setting concrete (ASTM C-494; Type A, D and G, ELOTEN934-2; T 11.1 and T11.2). Color - dark brown, dosage - 0.6...0.8 %.

ADJUM 110, liquid with polycarbonate effect, based on standard EN 934_2: T 3.1 and T 3.2. Reduces water consumption by 20%. Color - light brown. Dosage - 0.6...1.40%.

ADJUM 130, liquid with polycarbonate effect, based on the standard EN 934_2: T 3.1 and T 3.2. Reduces water consumption by 20%. The concrete mixture retains its plasticity for a long time. Color: dark brown. Dosage - 0.35 ... 0.70 % (of cement mass).

Let's consider one of them - Sika VisconCrete Hi-tech 4127, it can be used for any concrete mix. It maintains workability for a long time and meets the requirements of the standard:

- Workability retention time of about 240 minutes;
- High water reduction (up to 40%);
- Reduction of exotherm

Application:

- Production of high-quality ready-mixed concrete;
- Concreting at high temperatures;
- Concreting of massive structures;
- Long transportation time of concrete mix;
- Production of high-strength, waterproof, frost-resistant, crack-resistant and wear-resistant concrete:

Advantages:
• Maintaining workability (plasticity) for a long time (=240 min);
• High water reduction (up to 40%);
• Reduction of concrete exotherm;
• Production of massive, crackresistant structures;
• Obtaining concrete with low deformation shrinkage and creep;
• Obtaining concrete with adequate strength and water tightness;
• Obtaining concrete with high chemical resistance;
• Does not contain chlorides that cause corrosion of reinforcement.

It is known that the concrete mixture, before the hydration process takes place, is a multi-component polydisperse system, in which we can distinguish a twocomponent structure: macrostructure (gravel-cement mortar); Mesostructure (sand-cement dou-gh), microstructure (cement mass, consisting of cement and additives dissolved in the source). Within the framework of the study, we changed the microstructure of the standard concrete mixture in order to improve its physical and mechanical properties, as well as to increase the workability of the mixture in comparison with the standard mixture in order to conduct the technological process of concreting in accordance with the standards.

In the first experiment, we prepared concrete without additives, with a w/c ratio of 0.6. The cone settlement was 15 cm. Concrete samples were tested at the age of 7 and 28 days. At the age of 7 days, the strength was 12.69 MPa, and at the age of 28 days, it was 19.45 MPa.

Table 1. Composition of concrete prepared in the first experiment

Experiment I	Density	kg
w/c	0.6	
Cement	3.05	350
Water	1	210
Sand	2.58	1060
Gravel	2.62	710

Sum		2350

In the second experiment, we prepared admixed concrete with a w/c ratio of 0.4. We reduced the water content in the mixture using Sikament MR 50-S, adding 1% of the cement mass. The cone diameter was 16 cm. Concrete samples were tested at 7 and 28 days of age. The average data of the tested samples at the age of 7 days was 14.4 MPa, and at the age of 28 days it was 23.4 MPa.

Table 2. Composition of concrete prepared in the second experiment

Experiment II	Density	kg
w/c	0.4	
Cement	3.05	350
Water	1	140
Sand	2.58	1065
Gravel	2.62	795
Sikament	1.1	3.5
Sum		2353.5

In the third experiment, we also prepared admixed concrete with a w/c ratio of 0.36. We added SikaVisconcrete Hi-tech 4127, in an amount of 1.5% of the cement mass. The cone settlement was 19 cm. The average data obtained as a result of testing concrete samples at the age of 7 days was 20.1 MPa, and at the age of 28 days it was 34.41 MPa.

Table 3. Composition of concrete prepared in the third experiment

Experiment III	Density	kg
w/c	0.36	
Cement	3.05	350
Water	1	126
Sand	2.58	1090
Gravel	2.62	784
Visconcrete	1.07	5,25
Sum		2355,25

As expected, samples with a low W/C ratio showed higher data. In particular, a 33% reduction in the amount of water gave a 17% increase in the strength of concrete samples at the age of 28 days, while in the second case a 40% reduction resulted in a 77% increase.

Table 4. Data obtained as a result of testing the samples

	W/C	Additive	Additive % from cement mass	Strength of concrete 7 days (MPa)	Strength of concrete 28 days (MPa)	Concrete Slump cm
I	0.6	-	0	12,69	19,45	15 (S3)
II	0.4	Sika m-ent MR 50-S	1	14,4	23,4	16 (S3)
III	0.36	Sika Visco-ncrete Hi-tech 4127	1.5	20,1	34,41	19 (S4)

Conclusion

To predict the expected effect of an admixture in concrete, it is necessary to conduct a technical and economic calculation. In addition, we must take into account the additional costs of its use: cost, warehouse, transport highway, preparation unit, dispenser. Therefore, the admixture should be used where it will give us the greatest technical and economic effect.

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