SATBAYEV UNIVERSITY

Architecture and Civil Engineering

Volume 1 (2024), Issue 1, 18-21

https://doi.org/10.51301/ace.2024.i1.04

Effect of chemical admixtures on the durability of fine-grained concrete

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Abstract. Currently, high demands are placed on the quality of building materials, regardless of the purpose of the buildings being built or the structure. Concrete currently occupies a high position in the construction industry. In developing countries, the issue of urban transport infrastructure is relevant, including the construction of highways and the laying of a large number of metro lines and urban railways, and the laying of engineering systems that require the construction of a significant number of tunnels and other underground facilities using fine-grained concrete. All these structures require high-strength fine-grained concrete, currently increasing the strength and durability of concrete is successfully solved by modifying it. With the help of the influence on the structure formation of cement systems, the blog of additives makes it possible to obtain high-strength concretes with high corrosion resistance. As a rule, fine-grained mixtures have increased viscosity and reduced mobility compared to conventional concretes. The amount of air in compacted jet fine-grained mixtures is much larger than in conventional ones, and its removal is difficult due to the large viscosity structure of fine-grained mixtures and the dispersion of air in them.

Keywords: *sand, fraction, fine-grained concrete, superplasticizer, strength, filler.*

1. Introduction

As you know, sand has a higher voidness than a mixture of sand and crushed stone. If the cement content in mixtures is thinner than 1/3, the cement dough may not be enough to coat the sand grains and fill all the voids. In this case, there is an additional volume of pores, which is due to the shortage of cement dough. The same reasons will affect the strength of fine-grained concrete. And also when using mineral additives, in view of their high complexity of obtaining sufficiently durable fine-grained concrete is explained by the above-mentioned obligations.

The article analyzes the effect of plasticizing additives and different sand fractions on the compressive strength of fine-grained concrete. It was revealed that the Master Phebuild 1000 K superplasticizer and aggregates having fractions of 0.63 mm; 1.25 mm; 2.5 mm affect the increase in the strength of fine-grained concrete. It was found that with the combined use of aggregates and 0.5% of the cement mass of the Master Phebuild 1000K superplasticizer, it can increase the strength at the age of 7 calendar days by 35%, at the age of 28 calendar days by 30%.

In view of the above, it seems very relevant and permpective to continue research in this direction in order to increase the operational life of concrete stone. The elimination of this shortcoming of fine-grained concrete, improving their physical and mechanical characteristics, is possible with the help of the developed chemical additive Master Phebuild 1000 K.

The Master Phebuild 1000 K additive interacts only with the binder. When the additive is added to the mixture, it is absorbed by the binder particles. The binder particles repel each other due to the forces of electrostatic repulsion. Thus, the desired workability is obtained with less mixing water. Proportionally, with a decrease in the mixing water in the concrete mixture, the mechanical strength of concrete increases. The additive can be used with silica, fly ash and ground granulated blast furnace slag, where a high content of binders and fillers is necessary, for example, in the production of self-compacting concrete.

The introduction of a naphthalene sulfonate-based superplasticizer into concrete makes it possible to additionally fill the fluid mixture with sand and significantly reduce the specific consumption of water and cement.

Mechanisms of action of plasticizing additives: The mechanisms of action of superplasticizers in fine-grained concrete are similar to the mechanisms of their action in conventional concrete and are divided into 3 main categories:

- reduction of surface tension;
- plasticization with adsorption on soluble cement particles, accompanied by an anti-aggregation effect;
- by the action of air involvement.

The superplasticizer complies with the TS EN 934-2 standard and is highly water-reducing. Currently, no scientific study has studied the effect of Master Phebuild 1000K on the strength of fine-grained concrete. This issue has been resolved in this article, the results of the study are presented in the following sections.

2. Materials and methods

Portland cement without mineral impurities CEM I 42.5 R, conforming to EN 197-1, with a water consumption of 26.6%.

The mineral composition, physical and mechanical properties of cement are presented in Tables 1, 2, respectively.

Table 1. Mineral and chemical composition of cement

Component	[%]
Tricalcium silicate (C_3S)	57.9
Dicalcium silicate (C_2S)	15.6
Tricalcium aluminate (C_3A)	7.5
Tetracalciumaluminoferrite (C_4AF)	11.9

Table 2. Chemical composition of the cement

Component	[%]
Al_2O_3	5.23
Fe_2O_3	3.44
SiO_2	20.63
CaO	63.56
MgO	3.13
SO_3	0.78
K_2O	1.15
Na_2O	0.10
Cl-	0.007
CaO_{free}	1.4

Filler and water.

Natural river sand fraction 0.63; 1.25; 2.5, respectively, was selected as fine aggregates.

Drinking water was used as water for mixing concrete mixtures in accordance with the requirements of the EN 1008 standard.

Table 3. Technical specifications

Composition of the material	Based on naphthalene sulfate
Colour	Brown
Density	1.17 – 1.22 kg/l.
pH	6-8
Chloride content % (EN 480-10)	<0.1
Alkali content % (EN 480-12)	<10

Superplasticizer Master Phebuild 1000K.

Master Rebuild 1000K is used as a superplasticizer additive to improve the strength and workability of cement mortar. The technical specifications are given in Table 3.

3. Results and discussion

The composition of fresh cement mixtures are presented in Tables 4.5 and 6. In Tables 4, 5 and 6 of the compositions that specify the first composition consists of a sand fraction of 0.63 mm, the second composition of a sand fraction of 1.25 mm and the last with a fraction of 2.5 mm. these fractions were specially extracted using a sieve. The first three samples were mixed without a superplasticizer for comparison with the rest; the remaining three samples were mixed with an additive of 0.5% and the last 1% by weight of cement. When the W/C ratio changed, the amount of cement and water remained the same.. Control samples were prepared without additives.

The dosage of the additive was different for samples P1-P2 (0.5% and 1%).

Table 4. Composition of a mixture of fine-grained concrete with sand fraction 0.63 mm

№1	Cement, kg	Sand, kg	Master Rheobuild 1000 K, %	W/C
C0	0.55	1.500	0	0.4
P1	0.55	1.500	0.5	0.37
P2	0.55	1.500	1	0.35

Table 5. Composition of a mixture of fine-grained concrete with sand fraction of 1.25 mm

№ 2	Cement, kg	Sand, kg	Master Rheobuild 1000 K, %	W/ C
C0	0.55	1.500	0	0.4
P1	0.55	1.500	0.5	0.37
P2	0.55	1.500	1	0.35

Table 6. Composition of a mixture of fine-grained concrete with sand of 2.5 mm fraction

0	Cement, kg	Sand, kg	Master Rheobuild 1000 K, %	W/ C
C0	0.55	1.500	0	0.4
P1	0.55	1.500	0.5	0.37
P2	0.55	1.500	1	0.35

The cement mortar components were mixed according to the EN 196-1 procedure.

The weight proportions were one part cement, three parts sand 0/2 and a water/cement ratio of 0.4; 0.37; 0.35.

The plasticizing additive was mixed with water for mixing at high speed for 60 seconds to obtain a homogeneous dispersion. The mixing procedure was in accordance with the EN 196-1 standard.

After mixing the components from mobile concrete mixtures by vibration compaction, for 10 seconds, prisms with a size of 40×40×160 mm and sample cubes with dimensions of 100x100x100 mm were formed.

The test samples were prisms measuring 40×40×160 mm and cubes measuring 100×100×100 mm.

Cubes were molded to determine durability, prisms - to determine density, compressive strength..

The mold with the samples is covered with a plate material and placed in a laboratory. After (24±1) hours from the date of manufacture, the molds with samples are removed from the molds. The density and linear dimensions of cement prisms and cubes have been tested in accordance with EN 1015-1.

The labeled samples were horizontally immersed in water at a temperature of 20.0 ± 1.0^0C in containers.

After 7 days and 28 days, the mortars were tested for compressive strength in accordance with EN 196-1. These samples were periodically contrasted on a test press of the IP – 1A-500 brand and on a test press Model-With Controls.

Cement mortars prepared with additives in various ratios were tested to determine the strength.

The addition of a certain number of additives led to a decrease in the amount of water consumed and to an increase in compressive strength. Figure 1, obtained because of experimental work, show the effect of Master Rheobuild 1000K in the composition of a sand fraction of 0.63 mm.

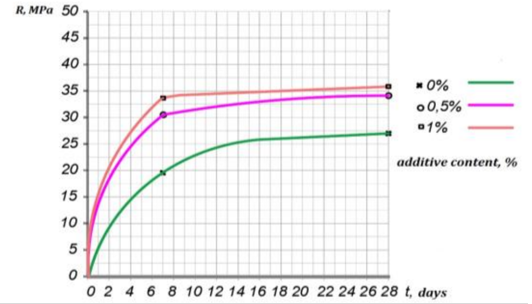

Figure 1. The effect of the sand fraction content of 0.63 mm and the Master Rheobuild 1000 K additive on the strength of of fine-grained concrete

The study found an increase in the strength of fine-grained concrete with the introduction of an additive of 0.5% for 7 days from 19.754 MPa to 30.249 MPa, and for 28 days from 26.6 MPa to 34.355 MPa. When adding an additive of 1%, the strength is changed in the following order for 7 days of hardening from 19.754 MPa to 33.535 MPa, for 28 days from 26.6 MPa to 35.762 MPa. In general, as the results show, for 28 days of hardening with an addition of 0.5%, the strength of fine-grained concrete increased by 22.65% with an additional 1% increased by 25.6%.

Figure 2, obtained as a result of experimental work, show the effect of Master Rheobuild 1000K in the composition of the sand fraction of 1.25 mm.

The study found an increase in the strength of fine-grained concrete with the introduction of an additive of 0.5% by 7 d from 22.624 MPa to 24.600 MPa, and by 28 d from 24.08 MPa to 33.39 MPa. But with the addition of an additive of 1%, the strength changes for the worse in the following order by 7 d of hardening from 22.624 MPa to 15.430 MPa, by 28 d from 24.08 MPa to 12.5 MPa. In general, as the results show, on 28 d of hardening with an addition of 0.5%, the yield of fine-grained concrete increased by 27.8% with an additional 1% decreased sharply by 48%.

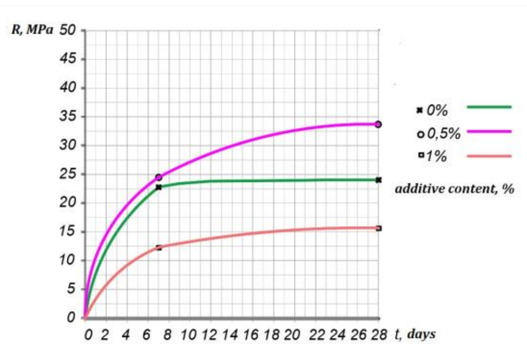

Figure 2. The effect of the sand fraction content of 1.25 mm and the Master Rheobuild 1000 K additive on the strength of fine-grained concrete

Figure 3, obtained as a result of experimental work, show the effect of Master Rheobuild 1000K in the composition of the sand fraction of 2.5 mm.

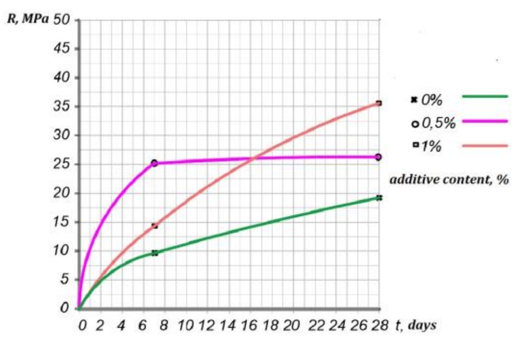

Figure 3. The effect of the sand fraction content of 2.5 mm and the MasterRheobuild 1000 K additive on the strength of fine-grained concrete

The study found an increase in the strength of fine-grained concrete with the introduction of an additive of 0.5% for 7 days from 9.959 MPa to 25.591 MPa, and for 28 days from 19.059 MPa to 26.55 MPa. But with the addition of an additive of 1%, the strength changes in the following order for 7 days of hardening from 9.959 MPa to 14.92 MPa, for 28 days from 19.059 MPa to 35.289. In general, as the results show, for 28 days of hardening with an addition of 0.5%, the yield of fine-grained concrete increased by 28.2% with an additional 1% increased sharply by 45.9%.

4. Conclusions

In this study, the technological properties of a hardened cement mortar containing a superplasticizer were studied. Based on the results of the experiment , the following conclusions can be drawn:

- The durability of cement-based materials depends on the W/C ratio. The weight-to-weight ratio can be reduced by using plasticizers and increasing the amount of air in the mixture. As a result, the durability of the cement mortar can be increased.
- As a result, the durability of fine-grained concrete increases the plasticizing effect. This effect leads to a decrease in open porosity and an increase in closed porosity and a significant increase in the durability of concrete.
- A stable increase in strength was established with the introduction of the Master Rheobuild 1000 superplasticizer, the maximum result shows an increase in compressive strength by 45.9% with an amount of 1% additive. On the other hand, the same amount of the additive showed a non-positive result in the composition of N2. As a result, you should choose the optimal amount to increase the strength of fine-grained concrete, plasticizing additives 0.5%. Accordingly, the same composition in all three experiments shows a positive result.

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Химиялық қоспалардың ұсақ түйіршікті бетонның беріктігіне әсері

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Аңдатпа. Қазіргі уақытта салынып жатқан ғимараттар мен конструкциялардың мақсатына қарамастан құрылыс материалдарының сапасына жоғары талаптар қойылуда. Қазіргі уақытта бетон құрылыс индустриясында жоғары орын алады. Дамушы елдерде қалалық көлік инфрақұрылымының проблемасы өзекті болып табылады, оның ішінде автомобиль жолдарының құрылысы және метрополитен мен қалалық теміржолдардың көптеген желілерін салу, сондай-ақ ұсақ түйіршікті бетонды қолдана отырып, тоннельдер мен басқа да жерасты құрылыстарын салуды қажет ететін инженерлік жүйелерді салу. Барлық осы құрылыстар жоғары беріктігі бар ұсақ түйіршікті бетонды қажет етеді, қазіргі уақытта бетонның беріктігі мен беріктігін арттыру оны өзгерту арқылы сәтті шешіледі. Цемент жүйелерінің құрылымына, қоспалар блогына әсер ету арқылы коррозияға төзімділігі жоғары беріктігі жоғары бетондар алуға болады. Әдетте, ұсақ түйіршікті қоспалар тұтқырлығы жоғарылайды және қозғалғыштығы төмендейді.

Негізгі сөздер: *құм, фракция, ұсақ түйіршікті бетон, суперпластификатор, беріктік, агрегат*.

Влияние химических добавок на долговечность мелкозернистого бетона

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Аннотация. В настоящее время к качеству строительных материалов предъявляются высокие требования, независимо от назначения возводимых зданий и конструкций. В настоящее время бетон занимает высокое место в строительной индустрии. В развивающихся странах актуальна проблема городской транспортной инфраструктуры, включающая строительство автомобильных дорог и прокладку большого количества линий метрополитена и городских железных дорог, а также прокладку инженерных систем, требующих строительства значительного количества тоннелей и других подземных сооружений с использованием мелкозернистого бетона. Все эти сооружения требуют высокопрочного мелкозернистого бетона, в настоящее время повышение прочности и долговечности бетона успешно решается путем его модифицирования. С помощью влияния на структурообразование цементных систем, блога добавок удается получать высокопрочные бетоны с высокой коррозионной стойкостью. Как правило, мелкозернистые смеси обладают повышенной вязкостью и пониженной подвижностью по сравнению с обычными бетонами. Количество воздуха в уплотненных струйных мелкозернистых смесях значительно больше, чем в обычных, а его удаление затруднено из-за большой вязкости мелкозернистых смесей и дисперсности воздуха в них.

Ключевые слова: *песок, фракция, мелкозернистый бетон, суперпластификатор, прочность, заполнитель.*

Received: 08 November 2023
Accepted: 16 March 2024
Available online: 31 March 2024