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Article

Research of foam concrete components in the regional production conditions of Nur-Sultan

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Abstract. The article presents results of the effect of one component of the modified additive (post alcohol bard) on the change in the setting time of the cement mixture. The work shows a method for determining the setting time, the selection of optimal composition of samples, which will accelerate the setting time (beginning and end). Performed a comparative study of cements from different manufacturers, as well as the effect of one component of the modified additive (post-alcohol bard) on the setting time. The research allows to determine the effect of plasticizing additive on the properties of foam concrete during their production. It is established that the introduction of the additive can reduce the time of the beginning and the end of setting, the introduction of additive (post-alcohol bard) in optimal quantities will accelerate the process of making foam concrete products. Obtained results of setting time in the samples using the additive led to the best results. In general according to the results of studies it can be concluded that the additive promotes the growth rate of plastic strength and setting of foam concrete mixture, accelerates the hardening of foam concrete and can reduce its shrinkage during hardening. Consequently, the additive is one of the most effective additives to accelerate setting and allows mortars to fully set in the shortest time intervals.
Keywords: modified additive, post-alcohol bard, setting time, foam concrete, plasticizer.

1. Introduction

Due to the rapid development of construction production has appeared many building materials, one of which is foam concrete. Foam concrete has various physical and mechanical characteristics, ease of production, low cost, a relatively small mass of blocks. Because of this, it became widely used in construction.

The basis of modern concrete technology is the creation of high-quality artificial stone, characterized by high dispersion, a small imperfection and structure stability. Improvement in quality of concrete compositions can be achieved both by use of chemical additives, and when using local components to create a new generation of concrete, which is a highly relevant objective of concrete technology. A new generation of concrete are high-tech, high-quality, multi-concrete mixtures and compositions with additives that preserve the required properties at a service in all operating conditions. Growing multicomponent concretes are due to significant systemic effects, what enables to manage the structure formation at all stages of the technology, ensuring receipt of composites of «directed» quality, composition, structure and properties [1-7].

The use of complex additives is now generally recognized as an effective way to improve the performance of cement concrete. In most cases, additives are now a mandatory part of the concrete mixture. Analysis of scientific and technical literature shows that additives increasing the rate of setting and hardening of cement are in demand, so the interest in the development of new, competitively capable accelerating additives is not weakening [8].

A wide range of domestic and imported chemical additives makes it difficult to make a choice. Concrete manufacturers seek to improve its properties by modification, while reducing the consumption of cement, reduce energy costs in the production of reinforced concrete, and minimize the cost of additives under stable terms of their quality. It is quite a challenging task that can be solved using a variety of waste and coproducts of many industries as mineral and chemical modifiers of concrete [9-13].

The main direction of intensification of technological processes in modern construction is the widespread use of various additives to cement-containing systems, among which plasticizers thinners are of great importance, allowing to significantly reducing the water consumption of concrete mixtures without reducing mobility. As plasticizers of cement mixtures surface-active substances are widely used either specially synthesized or by-products of various industries, many of which are environmentally unsafe [14].

Setting of concrete is identified as the transition of fresh concrete from liquid phase to solid phase. It is important to identify this phase change to plan transporting and placing of concrete [15].

In order to improve the technological properties, special additives are introduced into mortar mixtures, surface-active substances that have a plasticizing (post-alcohol bard) effect.

The aim of the study is to evaluate the setting time of cement mortars of different manufacturers for its further use in the production of foam concrete, as well as the effect of one component of the modified additive (post-alcohol bard) on the change in the setting time. The problem of utilization of post-alcohol bard formed during the operation of factories producing alcohol is still an urgent problem. Utilization (recycling) of post-alcohol bard and other undesirable impurities of production in a biotechnological way will ensure environmental safety of industrial enterprises producing alcohol (distillery and hydrolysis) by eliminating the discharge of bard into the environment.

In order to achieve the goal, the following tasks were solved:

1. Selection of the optimal composition of samples of compared cement mortars;
2. Laboratory studies of the setting time of samples with and without the addition of the component;
3. Comparative analysis of test results of specimens with and without component addition;
4. Selection of a cement manufacturer with optimal results of setting times, the most favorable for the production of foam concrete.

Comparisons of the results of laboratory tests carried out for the compositions:

Type-1: Reference sample without additives (Zhambyl-Cement);

Type-2: Sample with additive (3% post-alcohol bard) by weight of the reference cement (Type-1);

Type-3: Reference sample without additives (Central Asia Cement);

Type-4: Sample with additive (3% post-alcohol bard) by weight of reference cement (Type-3);

Type-5: Reference sample without additives (Kokshe-Cement);

Type-4: Sample with additive (3% post-alcohol bard) by weight of reference cement (Type-5).

2. Methods

Raw materials produced on an industrial scale were mainly used in laboratory studies. Their main characteristics as defined by the current standards are given below.

Portland cement M400 type CEM I 42.5 N (Karaganda (Central Asia Cement), Zhambyl-Cement and Kokshe-Cement) cement factory, which meets the requirements of GOST 31108-2016 [16].

The fine aggregate was quartz sand from quarries in Akmola region. Modulus of grain size – 2.7, meets the requirements of GOST 8736-2014 [17].

Alcohol production waste was used as a modifying additive (post-alcohol bard, produced according to TU 5870-002-14153664-04 [18], in an amount of 3% by weight of cement).

Tap water as mixing water for concrete mixture, corresponding to the requirements of GOST 23732-2011 [19].

Consumption of raw materials of cement mortar samples (required for measuring the setting time) are presented in Table 1. Mineralogical and chemical composition of cements CEM I 42.5 N from different manufacturers are presented in Tables 2 and 3.

Table 1 – Composition of cement mortar types compared

No	Type	w/c ratio	Cement	Post-alcohol bard	NaOH	Water
1	Type-1, 3, 5 Reference sample without additives	0.3	350	-	-	105
2	Type-2, 4, 6 Sample with additive (3% post-alcohol bard)	0.3	350	10.5	0.525	93.975

Table 2 – Mineralogical composition of cements CEM I 42.5 N

No	Type	C_3S	C_2S	C_3A	C_3AF
1	Zhambyl-Cement	57.27	14.87	8.28	14.28
2	Central Asia Cement	47.92	19.09	8.65	13.6
3	Kokshe-Cement	47.92	19.09	8.65	13.6

Table 3 – Chemical composition of cements CEM I 42.5 N

No	Type	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O_3	K_2O
1	Zhambyl-Cement	24.81	6.06	2.81	64.49	2.97	3.12	0.23	0.87
2	Central Asia Cement	27.16	5.92	3.03	63.67	2.75	3.03	0.26	1.01
3	Kokshe-Cement	27.52	5.79	3.33	59.10	2.36	3.01	0.28	1.02

Figure 1 – Determination of the setting time of the dough of standard consistency (beginning and end of setting)

Effect of additives on the time of setting of the cement system (as shown in Figure 1) was determined in accordance with the requirements of GOST 310.3-76 [20].

3. Results and Discussion

An important indicator of construction and technical cements is the setting time, because this indicator depends on how economically water is used as one of the important resources in construction and how long it takes to build.

Setting is the process by which a relatively mobile mixture of cement and water gradually thickens and acquires an initial strength such that its mechanical processing becomes practically difficult or even impossible. Therefore, binders, including cements, should be characterized by such a setting time, which makes it possible to prepare mortar and concrete mixes and use them in business. A distinction is made between the beginning and the end of the setting time of a particular binder. Conventionally, in accordance with the standards of these terms are determined on the test of normal density at 20°C by the depth of immersion in it the needle Vica. According to GOST 10178-85 [21] beginning of the setting of the dough, this binder should come not earlier than 45 minutes and the end of setting time not later than 10 hours, counting from the moment of mixing the cement with water.

In the experiments, we used three types of cement, which are the main Portland cement of mass production in the Republic of Kazakhstan, which have different mineralogical and material properties (Table 4). The results in the table show that the additive in sufficient quantities leads to changes in setting time compared with no additive composition, but within the standards established by GOST 10178-85 [21].

Table 4 – Setting times of Portland cements of different mineralogical compositions with additives

Type	Additive, % of binder weight	Cement	w/c ratio	Setting time, h-min beginning	Setting time, h-min end
Type-1	without additive	Zhambyl-Cement	0.3	3:20	6:50
Type-2	post-alcohol bard 3%	Zhambyl-Cement	0.3	2:10	5:20
Type-3	without additive	Central Asia Cement	0.3	2:45	6:10
Type-4	post-alcohol bard 3%	Central Asia Cement	0.3	1:30	4:10
Type-5	without additive	Kokshe-Cement	0.3	3:00	6:40
Type-6	post-alcohol bard 3%	Kokshe-Cement	0.3	1:55	4:40

Table 4 shows that all three cements under study had setting times that meet the requirements of GOST 10178-85 [21]. However, Zhambyl-Cement has a longer setting time than Central Asia Cement and Kokshe-Cement. The additive accelerated the beginning and the end of setting time of cements.

The values in the diagram (Figure 2) show how Portland cements will behave with the additive during mixing. Plasticizing additive decreased water consumption by 1.5 % for Central Asia Cement, by 1.2 % for Kokshe-Cement and by 0.5 % for Zhambyl-Cement when added in 3% of cement mass. In connection with this we can conclude that a certain reduction of water for kneading the mixture (by 20-25%) to obtain the dough of normal density leads to the features of hydrophobic and plasticizing additives.

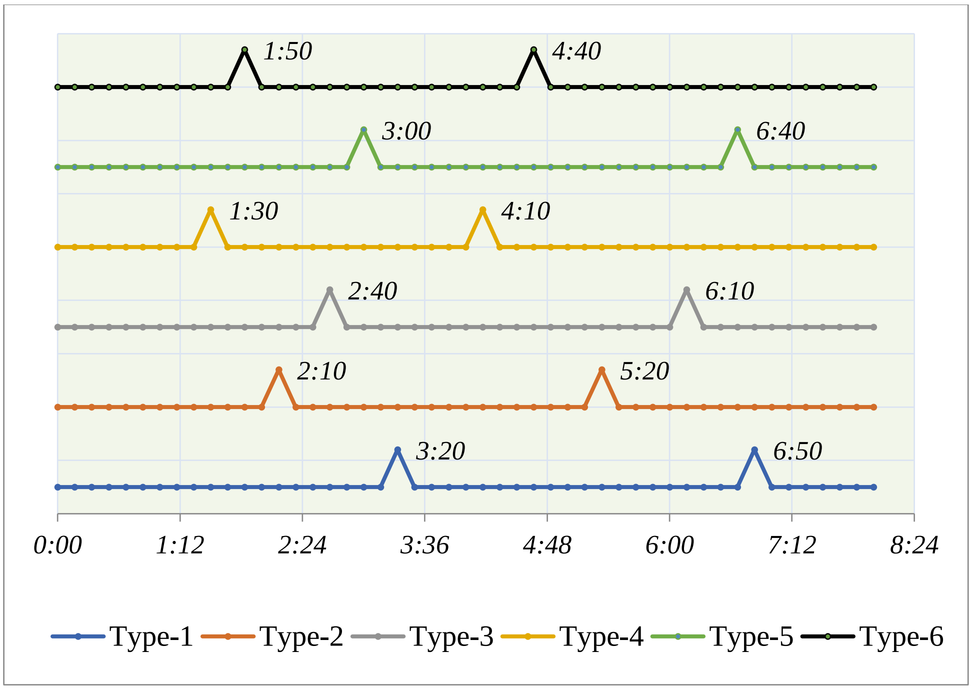

Figure 2 – Setting times of cements of different mineralogical compositions with an additive

According to the results of the study, determined the time of setting of the compositions for:

Type-1. The beginning of setting of the cement mixture without additive is 3 h 20 min, and the end of setting is 6 h 50 min.

Type-2. When adding 3% additive (post-alcohol bard) in the cement mixture, the beginning of setting time is 2 hours 10 minutes and the end of setting time of 5 hours 20 minutes, respectively.

Type-3. The beginning of setting of the cement mixture without the additive is 2 h 40 min and the end of setting 6h 10 min.

Type-4. When adding 3% additive (post-alcohol bard) in the cement mixture, the beginning of setting time is 1 hour 30 minutes and the end of setting time of 4h 10 minutes, respectively.

Type-5. The beginning of setting of the cement mixture without additive is 3 h 00 min and the end of setting is 6 h 40 min.

Type-6. When adding 3% additive (post-alcohol bard) in the cement mixture, the beginning of setting time is 1 hour 50 minutes and the end of setting time of 4h 40 minutes, respectively.

When comparing the time of setting of these cements made with mortars with and without additives, it was found that with the introduction of additives the difference is even more noticeable. Thus, the difference in the beginning of setting time is 2 hours 10 minutes and the end of setting time is 5 hours 20 minutes for Zhambyl-Cement, the beginning of 1 hour 30 minutes and the end of 4 hours 10 minutes for Central Asia Cement and the beginning of 1 hour 50 minutes and the end of 4 hours 40 minutes for Kokshe-Cement. The results convincingly prove the effectiveness of the proposed additive consisting of post-alcohol bard. The analysis of experimental data relating to the effect on the time of setting shows that the additive is more effective in 3% dosage. In general, according to the results of these studies it can be concluded that the use of the additive increases the growth rate of plastic strength and setting of foam concrete mixture, accelerates the hardening of foam concrete and is able to reduce its shrinkage during curing.

4. Conclusions

The following conclusions can be made on the basis of the experimental studies:

1. The use of cements from different manufacturers in the production of foam concrete makes its own adjustments in the properties of the cellular concrete mixture at the stage of forming and maturation of the mass.

2. Mineralogical composition of cement from different manufacturers affects the strength of concrete. Among the materials studied cement Zhambyl-Cement has the least, and Central Asia Cement and Kokshe-Cement - the greatest influence on the time of setting. Consequently, Central Asia Cement showed the best results of setting time in the samples using the additive (Type-4 beginning 1h 30 min, end setting 4h 10 min) for its further use in the production of foam concrete.

3. In accordance with the results obtained for the setting time in the samples, it can be said that the introduction of an additive with a volume of 3% leads to the maximum decrease in the necessary moisture for normal density in all cements.

4. The additive proved to be one of the most effective additives for accelerating setting, the introduction of this additive in an amount of 3% by mass allowed the mortars to fully set in the shortest time intervals. If an additive in the amount of 3% is added to the cement batter, the final setting will be faster in all cases.

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