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ALKALINE FLY-ASH CEMENTS AND CONCRETES· INFLUENCE OF CARE ON EARLY STAGE OF HARDENING

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Abstract

There are a lot of not well investigated processes in alkaline fly-ash cement technology Among them the role of fly-ash type and type of alkaline component in structure formation processes in different stages, new phases formation and connected with this properties of cements and concretes, including corrosion resistant, durability and other.

It was necessary to investigate influence of concrete care curing, humidity temperature on properties of fly ash-alkaline concrete, on their early stage strength, stability and possibility to self-destruction.

Also, it is important to now about strength development of different types of alkaline fly-ash cements and concretes on their base in time and special properties of such material, especially in case of investigation possibility to uncover fresh concrete surface.

Keywords: Alkaline cements, Alkali activated fly ash, concrete care, structure formation.

1. Introduction

At present industrial world, especially in the sphere of construction industry the question of processes duration became one of the most important. How to make construction duration shorter? How to decrease humans sources involvement? And firstly how to prevent decreasing of service properties of the final products using such limits? There are the problems we have to solve to be corresponding to the progress. The main reason – to save to the cement possibility to be hardening in normal conditions (to have enough water for hydration).

Underlined problem could be solved in different ways – by using special sprays covering the wet concrete surface), by covering fresh cement mortar or concrete by special insulation material (recommended according to the standards (DBN D2.2.6-99) or by adding special water-retaining additives. The first one requires application of extra machines to spray polymers, which are also not so cheep. So, such way causes some changes in technology and it is more expensive comparing with traditional. The second method is recommended in national Standards of different countries (DBN D2.2.6-99, VSN 139-80), but this is an old way which needs a lot of human sources and a lot of time. Now human work and time is a most expansive part of the constructions. That's why this way is not reasonable too.

In our opinion, the most perspective way to save enough water in cement matrix for the hardening processes is adding water-retaining components. Such method makes it possible to save standard technology but avoid the need for more activities. As additives could be used different fill-making components. So, this way has to be cheaper and more rapid that any other one.
The mention problems are inherent to the OPC mortars and concretes. But is it a huge problem for the alkali-activated binder systems?

The purpose of presents study were to determine influence of hardening conditions on service properties of concretes based on two types of alkaline cements, and to show possibility to reduce negative factors on it.

2. Experimental

Two alkali-activated cements were used: "fly ash OPC" (compositions O) and "fly ash – OPC ground blastfurnace slag" composition C).

As a main component of alkaline cement a typical class F fly ash from a Ukrainian power plant was used chemical composition is shown in Table 1), grinded to Blaine specific surface of 556.6 m^2/kg.

As a Ca- containing component were used ground blastfurnace slag (specific surface 4517 sm^2/g) and OPC (specific surface 3517 sm^2/g).

As a main alkaline component of dry cement compositions and concretes on their base were used sodium metasilicate and sodium carbonate.

All dry components were mixed before making concrete in a laboratory mill.

Table 1 Chemical compositions of raw materials

Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	L.O.I.
Fly ash	51,08	24,8	13,67	3,12	1,83	0,08	0,60	1,90	1,50
Type I OPC	23,40	5,17	4,12	64,13	0,88	0,55	0,41	0,33	0,20
Blastfurnace slag	40,00	5,91	0,32	46,98	5,87	1,62			

For both systems concrete samples were curing in different ways:

- Composition 1 was hardening at 5°C, composition 2 was hardening at 22°C.
- After 7 days of hardening at 5°C samples of composition 1 were divided at two parts: first one stays hardening at 5°C, other one comp.3) were set at temperature 22°C in air conditions.
- Composition 2 stays hardening in water at 22°C.

Concrete mix was prepared in laboratory compulsory concrete mixer

Samples has cubic form with a size of 100 mm.

Water-retaining additives were used in dry form and mixed with the dry cement composition.

Influence of this additives were tested both on concrete and cement mortars.

Photos of Concrete surface were taking with digital camera and microscope "Dino-Lite" (for concrete and mortar crack area after testing).

3. Results and discussion

3.1 Cement system "fly ash – OPC - ground blastfurnace slag"

For the traditional OPC binder systems and concretes on their base it is a critical to save normal temperature conditions during early stages of hardening, because at 8 degrees hardening processes became much more slowly and at 5°C they are mostly stops. So it became necessary to make some additional operation on concrete care – to fill wet concrete surface, to head constructions and other.

It was interesting to investigate how alkali-activated cement, especially fly ash-based, will be hardening at critical conditions. At that reason an experiment on influence of decreased temperature on hardening processes for concrete based on two mentioned binder systems was proposed.

Concrete compositions were taken according to the Ukrainian standards for testing additives efficiency and so were not optimized.

Results of concrete tests are in Table 2.

Table 2 Concrete based on cement system "Fly ash OPC ground blastfurnace slag" compositions and test results

№	Concrete composition per 1 m^3				W/C	Flow ability mm	Strength, age, MPa.		
	cement	sand	aggregate 5-10 mm	aggregate 10-20 mm			3 days	7 days	28 days
O1	350	780	330	830	0,5	230		5.5	19.7
O2	350	780	330	830	0.5	230	6.5	15.9	24.5
O3	350	780	330	830	0.5	230		5.5	29.2

After 3 days composition 1 had not strength to test. At 7 day of hardening it takes some strength, but still was lower a triple comparing with comp.2

It is important to admit that there are no any problems with hardening process on concrete, no surface leaching or cracks.

Concrete structure photos at early stages are shown see Figure 1

At 28 days age comp 3. not even achieve strength rate of comp 2, but a little bit exceeds it. Comp.2, which were hardening at low temperature, characterized with a strength lower for 20% comparing to normal one.

The results shows the possibility of concretes based on "fly ash – OPC – ground blastfurnace slag" cement system to be hardening at the low temperatures.

In other hand, at high temperature at 25°C and more or low humidity there are a problems connecting with drying of the concrete surface, that also makes it impossible to save normal hardening processes. So, it is necessary to make some fills on the surface, spray water or make something else.

To prevent drying of the concrete surface was analyzed the influence of film forming additive on the properties of the concrete. Since some preliminary industrial studies revealed damage of the concrete surface based on such cement, further investigation was performed for this composition.

To determine the effective input of additive to the concrete mixes were used a dry powder additive at the rate of 1.0 % by mass additives on the dry mater of cement.

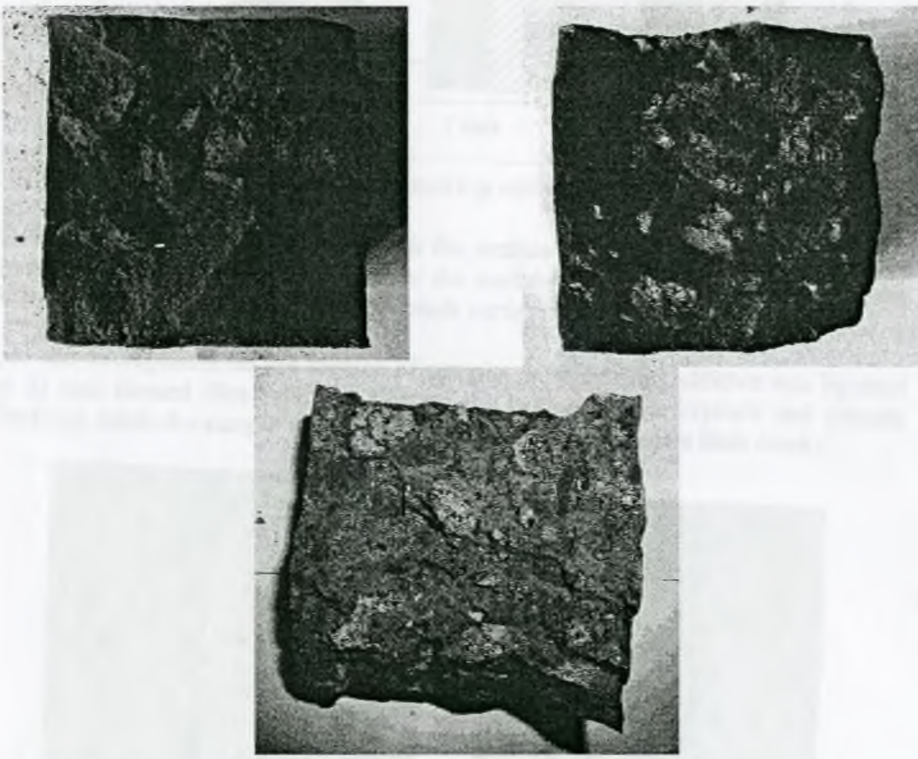


Figure 1 Structure of concrete after testing:
a) comp.2 at 3 days; b comp.2 at 7 days; c comp.1 at 7 days.

Results of tests of concrete with additive and the control of the mixture (see Figure 2) showed that the experimental concretes using complex additives have on the concrete surface film that prevents the formation of cracks, creating a barrier to migration of water surface. Concrete compositions with and without additives had the similar strength at all stages of hardening and correspond to the class of B20.

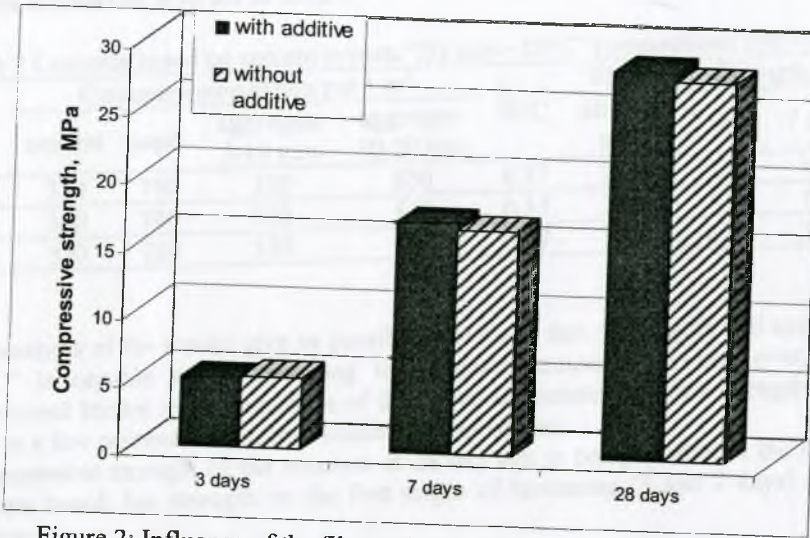


Figure 2: Influence of the film-making additive on concrete strength

To monitor the efficiency of forming a film on the surface of concrete, which is protected from dry air, compared with concrete to secure the surface by coating the surface of fresh concrete with plastic wrap, conducted research crack surfaces with the aid of Dino-Lite.

According to the microphotos on the surface of samples in which the additive was injected (see Figure 3) was formed film (you can capture the brilliant white crystals and smooth surface reflection), while the sample without additives (Figure 3, b shows little cracks.

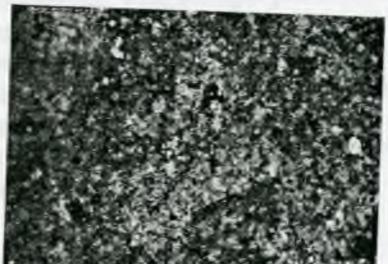
a)  б) 

Figure 3. Microphotos of concrete samples without (a) and with additives (b

An analysis of the results shows the efficiency of using film-forming agents. It could be used for constructions of important constructions with a big length, like roads, bridges, dams etc.

3.2 Cement system "Fly ash – OPC"

Previous investigations results(Krivenko, P V., Kovalchuk, G.Yu. 2007) shows that alkali-activated fly ash based system with Ca activator of OPC had higher service properties in decreased temperatures comparing with system "Fly ash – OPC – Blastfurnace slag" So, it were taking some studies to check efficiency of the present system to be hardening in critical low temperature or at changeable conditions.

Results of concrete tests are in table 3.

Table 3 Concrete based on cement system “Fly ash OPC” compositions and test results

№	Concrete composition per 1 m³				W/C	Flow ability mm	Strength, age, MPa,		
	cement	sand	aggregate 5-10 mm	aggregate 10-20 mm			3 days	7 days	28 days
C1	350	780	330	830	0.37	230	6.22	10.5	22.3
C2	350	780	330	830	0.37	230	7 14	11.9	25.1
C3	350	780	330	830	0.37	230	6.22	10.5	24.7

An analysis of the results give us possibility to claim that alkali-activated system “Fly ash OPC” is capable to be hardening in decreased temperatures. Moreover, concretes on mentioned binder in the condition of decreased temperatures shows strength characteristics just in a few percents lower, than standard compositions.
Compressive strength of the concrete at 28 day age is compressible to the previous binder system based, but strength on the first stages of hardening (3 and 7 days are much more higher.

4 Conclusions

Alkali-activated fly ash-based cements are able to hardening in decreased temperature conditions. It is necessary to admit that decreased strength properties which are typical to the hardening at low temperatures goes up and take a standard value after placing samples in normal conditions. Moreover binder system “fly ash OPC” under hardening at 5°C characterized with strength just a little bit lower than the same in normal one. This makes it possible to use such cements for making concretes in low temperatures without adding any extra additives.
Using a water-retaining additives in the concrete compositions opens the way to reduce a few negative phenomenon as, for example, leaching. Such methods could be used both for alkaline cement systems and OPC mortars and concretes during construction long and huge objects (roads, bridges, dams and etc.).

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