THE WATER TRANSPORT OF Na^+ - IONS IN FLY ASH BASED ALKALI-ACTIVATED CEMENTS STONE

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Abstract

The main distinction of fly ash and slags based alkali activated cements from OPC is that alkaline environment appears immediately after mixing with water and so because of high pH level it takes place more intensive destruction of covalent bonds, promoting formation of lower basic hydration products, which provide dense and homogenous structure of artificial stone.

Fly ash based alkali activated cements are differ from slag alkali activated cements by lower speed of structure formation processes, that provide longer term of existence of Na^+ *ions in unbounded state and needs more time to procuring conditions of hardening which are preventing of this ions transfer to the surface of specimen.*

In present study were investigated processes of Na^+ *ions mass transfer in artificial stone of fly ash based cements (up to 70% by mass) under influence of temperature and humidity gradients. It was shown possibility to use hydrophobic and redispersing admixtures, which provides slowing mass transfer processes of alkaline ions in the volume of concrete structure until their bonding into non-soluble compositions. This makes it possible to develop technology of concrete manufacture regardless hardening conditions.*

Key Words: *fly ash, alkali activated cements, redispersing admixtures, hydrophobic admixtures, air-dry conditions of hardening.*

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1. INTRODUCTION

Development of modern technologies of construction is focused at development of effective materials, usage of which is economically rational, gives possibility to cut the economic costs and raw materials consumption, to utilize industrial wastes. That is why development of energy saving technologies of manufacture of building materials with high industrial wastes content, such as coal fly ashes and metallurgical slags [1, 2], is an actual goal. According to the principles of constant development usage of ashes and slags in the cement composition will give possibility not only to reduce mineral resources consumption, but also to improve ecological environment.

Usage of high amount of fly ash in binders could be problematically taking into account not stable chemical-mineralogical composition of such wastes, because artificial stone on their basis is characterized by retarded strength gain in the initial ages of hardening and by degradation of exploitation properties.

From the point of view of increasing of effectiveness of fly ashes usage in the cements and concretes on their basis a huge interest causes alkali activated cement [5-8], developed in the State research institute for binders and materials named after V.D. Glukhovskii, Kyiv, Ukraine. In comparison to blast furnace slags fly ashes are characterized by lower activity. That is why fly ash alkali activated cements (AAC) are characterized by slower strength gain in initial terms of hardening that needs creation of standard conditions of hardening, which could exclude process of leaching of alkaline metals on the concrete surface before their bonding into the non-soluble phases. This limits application of concretes on fly ash AAC basis in monolithic constructions [6, 9].

Purpose of study is investigation of Na+ ions mass transfer processes in concretes on fly ash AAC basis under influence of temperature and moisture gradients and determination of possibility of retarding such process by introducing admixtures with redispersive and hydrophobic action.

2. RAW MATERIALS AND TEST METHODS

As a raw materials was taken low basic fly ash class F (according to ASTM C 618), grinded to the specific surface 800 m^2/kg, as an alkaline component was used sodium carbonate (technical grade). For activation of cement systems it were used OPC class 52.5 with specific surface 380 m^2/kg and granulated blast furnace slag, ground to the specific surface 450 m^2/kg. Chemical composition of raw components is given in Table 1.

Table 1: Chemical composition of raw materials

Component	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	SO_3 %	Na_2O %	K_2O %	Mass loses %
Fly ash	51.08	24.8	13.67	3.12	1.83	0.08	0.60	1.90	1.50
OPC 52.5	23.4	5.17	4.12	64.13	0.88	0.55	0.41	0.33	0.20
Slag	40.0	5.91	0.32	46.98	5.87	1.62	-	-	-

Alkali activated cements were prepared by separate grinding of fly ash and slag and mixing of all the components with alkaline activator and plasticizer in the ball mill.

Object of investigation was concrete on fly ash alkali activated cement basis classified according to the standard [10] as pozzolanic alkali activated cement ЛЦЕМ V. Composition of fly as alkali activated cements is given in Table 2.

Table 2: Composition of fly ash alkali activated cements

Cement type	Composition, % by mass				
	Fly ash	OPC 52.5	Slag	Alkaline component	Plasticizing admixture
ЛЦЕМ III	66.2	28.4	-	Na_2CO_3-4.7	0.7
ЛЦЕМ V	56.7	9.5	28.4	Na_2CO_3-4.7	0.7

Determination of peculiarities of cement composition structure forming processes was done by using a complex of physical-chemical and physical-mechanical methods on artificial stone specimens. Studies of Na^+ mass transfer processes were done by using probe microscope analysis on microscope PEMMA 102 (fig. 1) at specimens with dimensions B = 70 mm, H=70 m. Specimen was prepared but cutting of cube 70×70×70 mm on 7 layers (70×70×10mm) (fig.2), at each level a few points were scanned at the surface. Concentration of Na_2O was taken as an object of study.

3. RESULTS AND DISCUSSION

Studies of Na+ ions mass transfer processes in concretes on fly ash AAC basis were done by using probe analysis as without admixtures so as with introducing of admixtures (redispersive («Neolith P 6000») and hydrophobic (calcium stearate) action), which were hardening in air-dry conditions (t = 20+5 °C, W = 65%) and at the constant low temperature (t = +5 °C W = 90%). Investigations were done at 3, 7 and 28 days of hardening (fig. 3). Concentration of alkalis in concrete at the 1 day of hardening was about 1.48 % by mass calculated in Na_2O.

Taken results of studies (fig. 3) witnesses that concentration of Na_2O in concrete being hardening at the temperature t = 20+5 °C and air humidity W = 65 % at third day is within the ranges 0.68…1.2 (fig. 3, 1-a), when Na2O concentration in concrete, being hardening at low temperature +5 °C and humidity W = 90 % - within the ranges 1.06…1.38 (fig.3, 2-a). This could be explained by retarding of hydration processes at lowered temperatures.

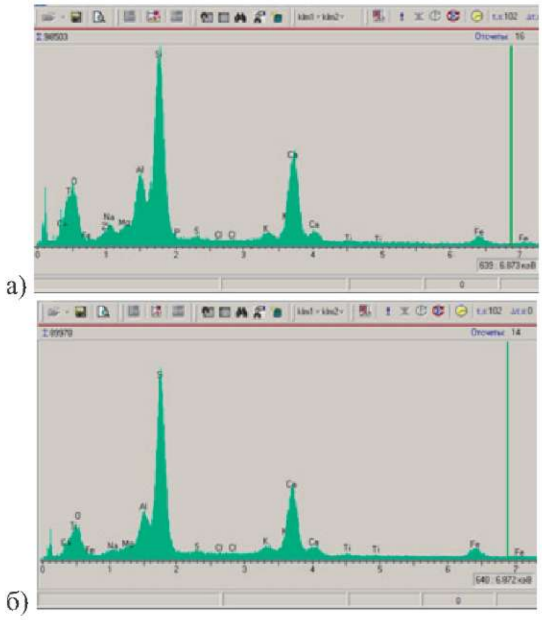

Fig. 1: Microprobe analysis of artificial stone by elements: a – without admixtures; б – with calcium stearate

So as data of sodium ions distribution is a random variable, results of study were analyzed by mathematical methods of calculation.

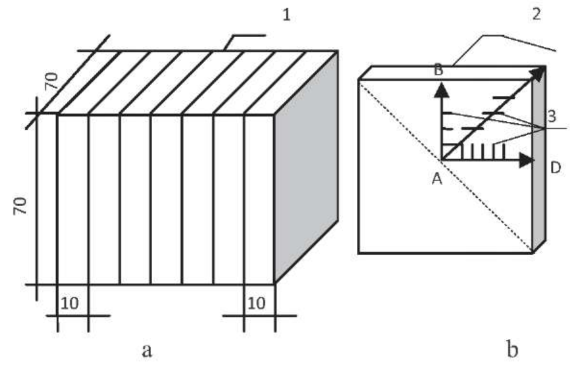

Fig. 2: Scheme of specimens preparation for tests of Na_2O distribution: a – specimen; b – scheme of specimen cut; 1 – levels (layers), 2 – directs of scanning (A-B, A-C, A-D), 3- points of scanning.

Analyzing diagrams of Na_2O distribution in concrete at 28 days of hardening at different temperatures it has to be mentioned that concentration of Na_2O in concretes with admixtures with hydrophobic (calcium stearate) and redispersive (Neolith P 6000) action is considerable lower and distributed uniformly from the specimens center to the surface and lays within the ranges 0.2…0.38 % – while hardening at t = 20+5 °C and air humidity W = 65 % (fig. 3, 1-c), and at lower temperature t = +5 °C W = 90% – 0.48…0.96 % (fig. 3, 2-c), whereas in concrete without admixtures it is observed sharp increasing of Na+ ions at the specimens surface.

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1.Air-dry conditions (t = 20+5 °C, W = 65%)

2. Constant low temperature (t = +5 °C W = 90%)

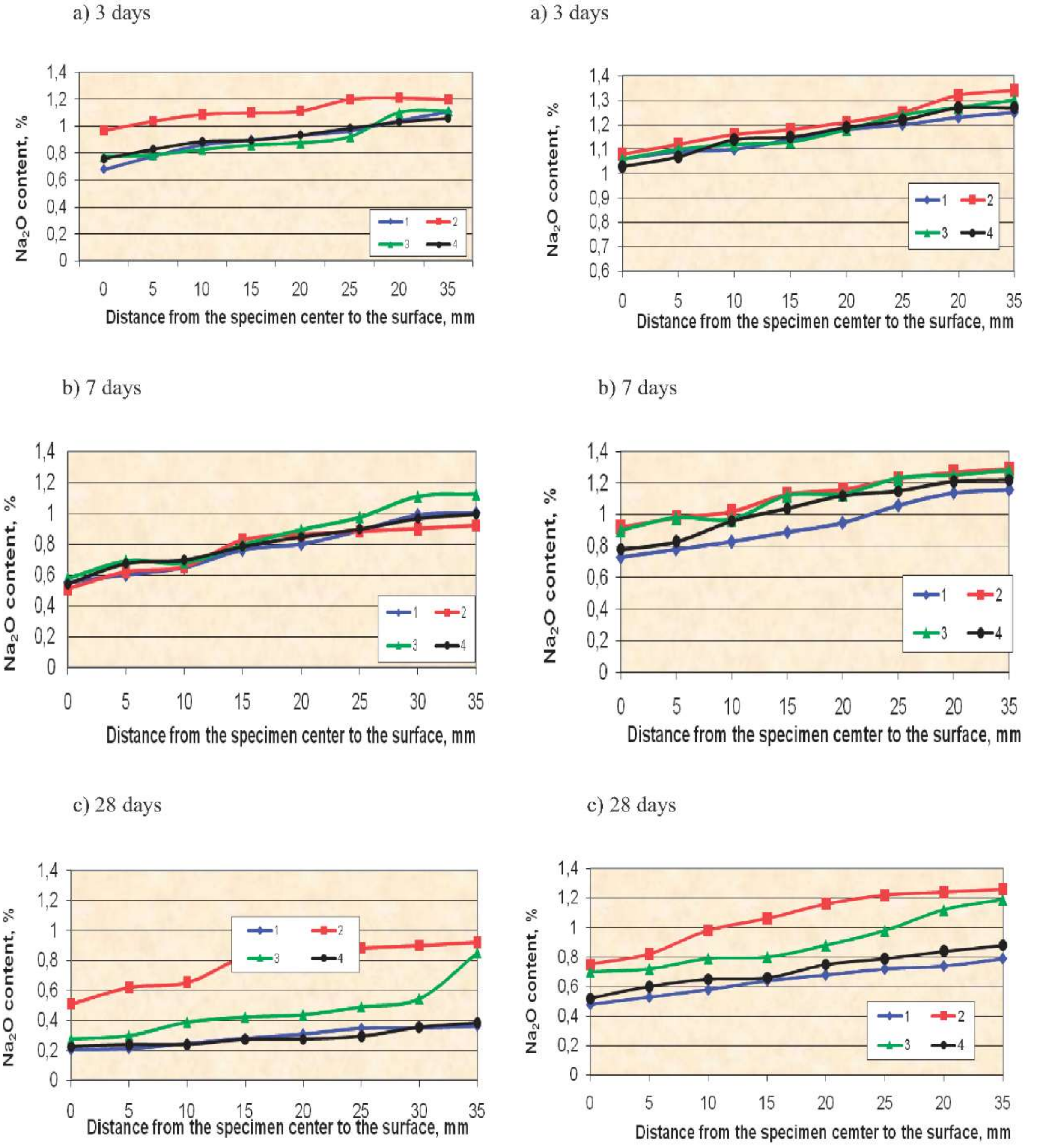

Fig. 3: Diagrams of Na_2O mass transfer in concrete after hardening:

system 1 – "fly ash – slag – OPC– alkaline component – surfactant admixture – Ca stearate", 2 – "fly ash – OPC – alkaline component – surfactant admixture", 3 – "fly ash – slag – OPC – alkaline component – surfactant admixture", 4 – "fly ash – slag – OPC – alkaline component – surfactant admixture – Neolith"

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Thus, it is shown that introducing of admixtures with redispersive and hydrophobic action to the concrete composition on fly ash AAC basis in general case provides possibility of retarding of Na+ mass transfer processes independently from temperature and moisture gradients.

Structure of concretes on fly ash AAC basis with admixtures of calcium stearate and Neolith P 6000was studied by using SEM microscope PEMMA 102. Micro photos of surface cleavage were done at 28 days of hardening (fig. 4).

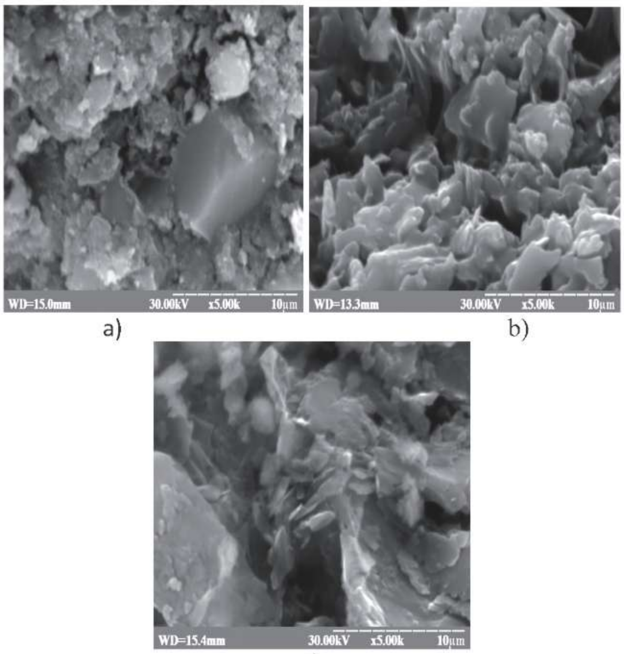

Fig. 4: SEM micro photos of ЛЦЕМ V-400 artificial cement stone: a – without admixtures; b – with calcium stearate; c – with "Neolith P 6000"

CONCLUSION

In result of provided investigations of Na+ ions mass transfer processes in concrete on fly ash alkali activated cement basis under influence of temperature and humidity gradients it was shown possibility of this process slowdown by using admixtures with redispersive and hydrophobic action in cement composition.

Usage of admixtures with redispersive and hydrophobic film-forming action make it possible to wide application area of concretes on fly ash alkali activated cement basis.

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