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Case study

The effectiveness of use of the composite binder as a dry mix

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ABSTRACT

The results of studies on the effectiveness of the use of synthetic aluminosilicates as structural supplements. Physico-chemical processes of hardening of cement stone and cement-based composites. Conducted X-ray diffraction and differential thermal analyses (XRDA and DTA) of the cement stone samples. The properties of dry adhesive mixture based on cement with the use of aluminosilicate supplements.

1. Introduction

For finishing and restoration of buildings and structures, dry mixes are widely used. In this regard, one of the priorities of modern construction materials science is the development of effective dry mixes with low cost, which enhance the performance properties of coatings. The solution to this problem is based on the intentional shaping of the material structure as a heterogeneous multiphase system of complex hierarchy. One of the ways to control the structure and properties of such a system is the addition of various modifying additives in the formula of different dry mixes (Strokova et al., 2010; Goregliad and Sapacheva, 2011; Kuo et al., 2006; Vejmelková et al., 2012; İşçi et al., 2005; Luckham Paul and Rossi, 1999; Swaminatham and Kildsig, 2002; Loganina et al., 2014a).

Previous studies proved the effectiveness of use of synthetic aluminosilicates in the formula of dry mixes as modifying additives (Loganina et al., 2014a,b).

2. Experimental

The paper suggests the use of composite cement binder, made with the use of synthetic aluminosilicates, in slab dry mixes. The aluminosilicates were synthesized through their precipitation from the solution of technical aluminum sulfate of technical $Al_2(SO_4)_3$ with sodium silicate, followed by washing the resulting precipitate with water and drying it (Loganina and Ryzhov, 2015).

The study of the physical and chemical processes of composite cement binder solidification was carried out with the help of X-ray diffraction and differential thermal analysis (XRDA and DTA) of cement stone samples, solidified in air-dry conditions. In the experiment Volsky portland cement brand 400 was used.

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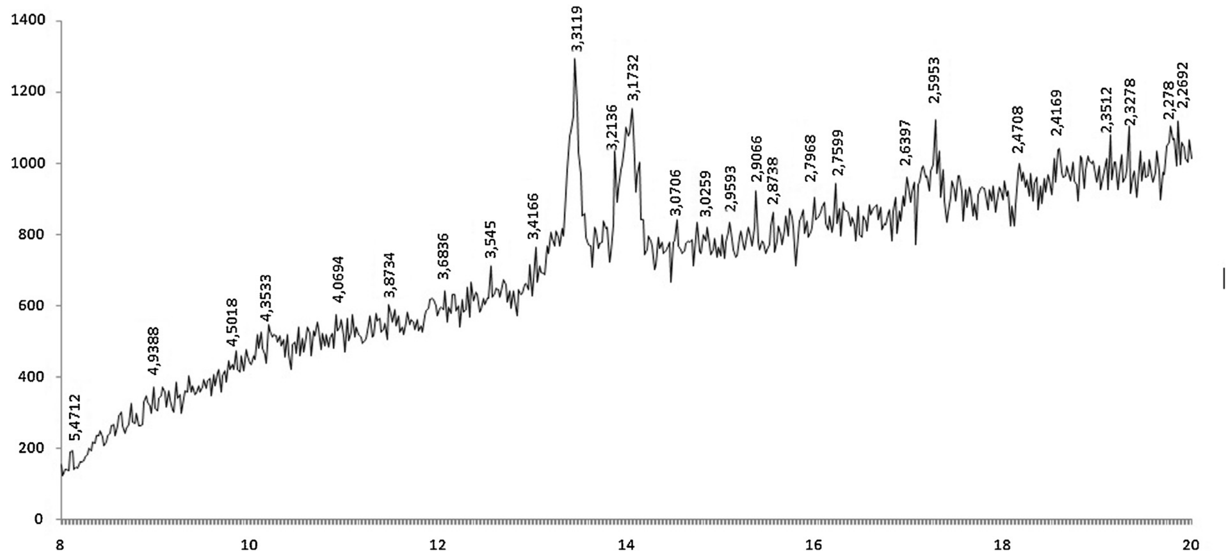

Fig. 1. X-ray of the cement stone.

3. Results

The results of the analysis of the phase composition of cement stone with/without synthesized aluminosilicate, conducted with the use of ARL 9900 X-ray WorkStation (ThermoScientific) at the Center of High Technologies BSTU. V.G. Shuhova are shown in Fig. 1 and Fig. 2 respectively.

Analyzing the data it can be asserted that the cement stone made with the use of synthesized aluminosilicate has more hydrate formations which was further confirmed by differential thermal analysis (DTA) (Figs. 3 and 4).

4. Discussion

Fig. 1 shows that the cement stone at small angles (up to 20°) has the mineralogical composition of the following compounds: hydrosilicates CSH (d = 5.4712; 4.3533; 3.54499; 2.9593; 2.9066; 2.8738; 2.7599; 2.6397; 2.5953; 2.3278; 2.278; 2.2692), ettringite (d = 4.9388; 3.8734; 2.4169), cristobalite (d = 4.0694; 2.4708; 2.3512), zeolite (d = 3.6836; 3.4166), tobermorite (d = 3.2136; 2.7968; 3.0706) (Larionova, 1971).

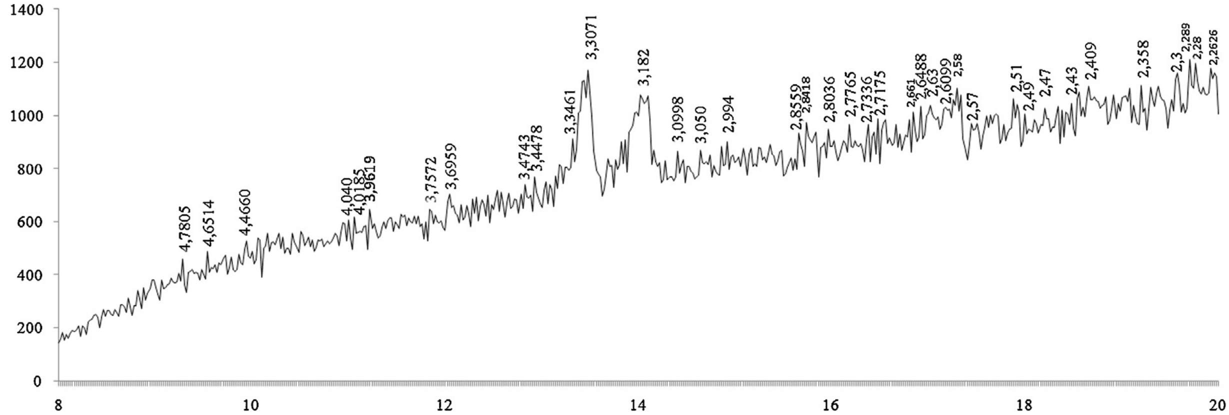

Fig. 2. X-ray of the cement stone with the synthesized aluminosilicate During the thermal analysis the temperature ranged from 30 to 1000 °C, the rate of temperature increase in the chamber was 3 °C/min, and the duration of a single experiment was about 5 h and 10 min.

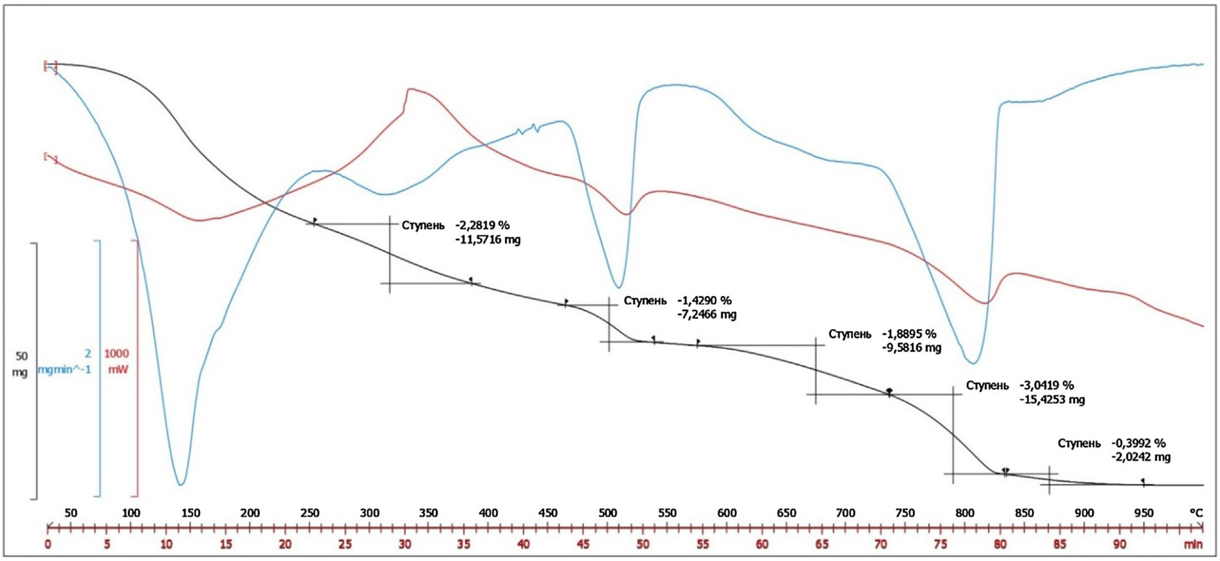

Fig. 3. The control sample thermogram.

The mineralogical composition of cement stone with synthesized aluminosilicate at small angles (up to 20°) includes the following minerals: hydrosilicates calcium CSH (*d* = 2.409 Å; 2.47 Å; 2.6488 Å; 2.7175 Å; 2.7336 Å; 2.8036 Å; 2.8418 Å; 3.050 Å; 3.0998 Å; 3.182 Å; 3.3071 Å; 3.6959 Å), calcite (*d* = 2.2626Å; 2.28 Å; 2.49 Å), $Al_6Ca_4O_{13} \cdot 3H_2O$ (*d* = 2.289 Å), $Na_{8.4}Ca_{3.2}Si_{36.4}Al_{11.6}O_{96} \cdot 5H_2O$ (*d* = 2.994 Å), borerit (*d* = 3.4743 Å), C_3S (*d* = 2.30 Å; 2.6099 Å; 2.63 Å), CAH_{10} (*d* = 2.358 Å), ettringite (*d* = 2.43 Å; 4.4660 Å), $CaOAl_2O_3$ (*d* = 2.51 Å), hydrocarboaluminates calcium (*d* = 2.57 Å; 3.3461 Å), zeolite (*d* = 2.58 Å; 3.9619 Å; 4.7805 Å), CASH (*d* = 2.661 Å), albit (*d* = 2.7765 Å; 3.4478 Å; 3.4743 Å; 3.7572 Å; 4.0185 Å; 4.040 Å) (Fig. 2).

The analysis of the thermograms (Figs. 2 and 3) showed that the endoeffect of the cement stone sample with synthesized aluminosilicate at the temperature of 150 °C is greater than the one of the control sample, indicating that the presence of a large number of hydrosulfoaluminate calcium. Endoeffect at 320 °C indicates that in the cement stone cubic hydroaluminate C_2AH_6. is formed Due to the water-retaining properties of the additives based on synthetic aluminosilicates, the solidification of the cement stone on the basis of composite cement binder takes place under more favorable conditions. The

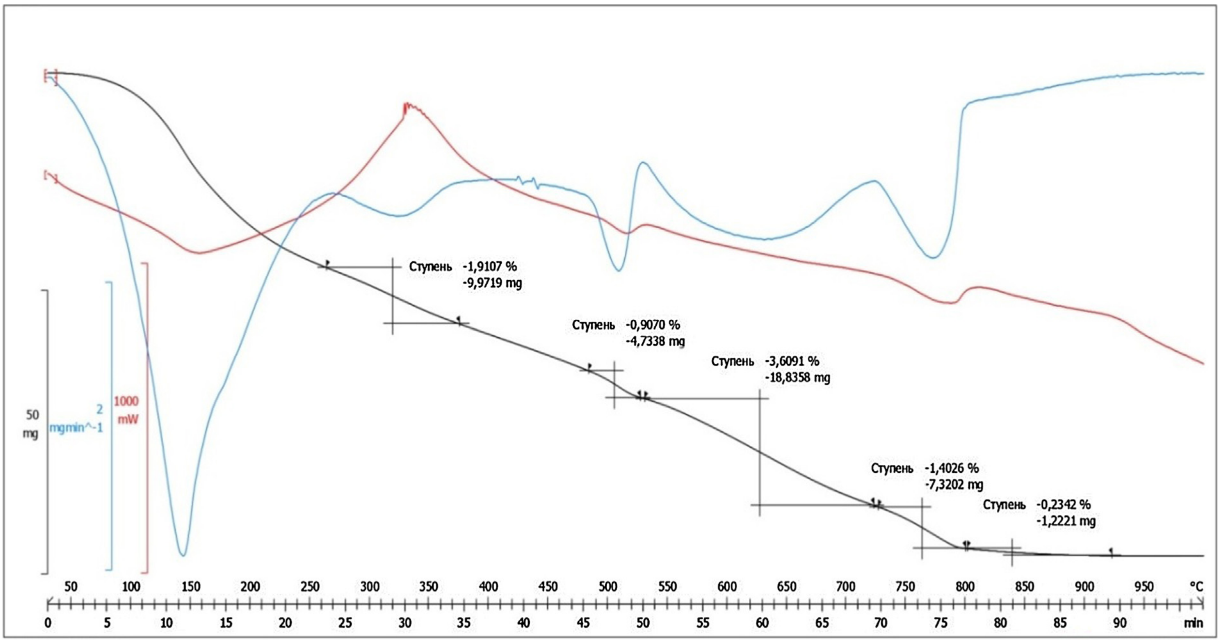

Fig. 4. Thermogram sample of the cement stone made with the use of synthesized aluminosilicate.

Table 1
Characteristics of the composite cement binder.

Content of the additives, %, by weight of cement	The normal density of the cement test, %	Setting time		The limit of compressive strength under air-dry hardening at the age of 90 days
		Beginning	End	
–	28	2 h 30 min	5 h	23,89 MPa
20	41	40 min	1 h 30 min	38,1 MPa

Table 2
Physical and mechanical properties of block glue.

Name of the indicator	Indicator value
The bulk density of the dry mixture, ρ, kg/m^3	1100
The water-holding capacity of the solution, %	95
Compressive strength, R_c, MPa	35,8
Adhesion strength, R_{adh}, MPa	1,2
Cohesive strength, R_{coh}, MPa	2,23
under normal conditions	1,9
in water-saturated condition	1,6
after 50 cycles of freezing and thawing	
Mark on frost resistance	F50
Time correction, min	20
Tile sliding, mm	0,3
The viability of the solution, min	100

decreasing intensity of endoeffect at a temperature of 510 °C, which indicates the dehydration of $Ca(OH)_2$, shows that the sample based on the of composite cement binder has less portlandite in it.

There is a more distinct endoeffect at the temperature of 810 °C, at which the dissociation of $CaCO_3$ occurs, in the samples of cement stone (the base composition) in comparison to the cement stone based on composite cement binder. Exoeffect at 550 °C is very distinct in the sample based on the composite cement binder, which indicates the presence of calcium hydroaluminate SAN10 in the cement stone composition.

The properties of the composite cement binder are given in Table 1.

The research has shown the effectiveness of use of synthesized aluminosilicate in the cement compositions as water-retaining and structure-forming additive.

We offer the formula of dry adhesive cement-based mix that can be used as block glue for coating facades and interior walls of buildings with ceramic tiles. The formula consists of portland cement, mineral filler (sand), plasticizer, polymeric and mineral supplement.

Below are the properties of mortars and coatings based on the developed formula of block glue (Table 2).

5. Conclusion

1. Thus, the studies and the calculations show the effectiveness of use of synthesized aluminosilicates in cement composites as structure-forming additives.
2. The addition of synthesized aluminosilicates in the formula of cement based block glue as modifying additives improves the properties of dry mixes.

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