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The Lime Compositions for the Restoration and Decoration of Buildings

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Abstract
Hereby provided these information about the patterns of structure of calcareous compositions with additives synthesized aluminosilicate. It is shown that supplementation of aluminosilicates accelerated the curing.

Keywords: dry lime mortar, aluminosilicate synthesis, structure, strength.

INTORDUCTION
Studies conducted earlier have confirmed the effectiveness of the use of the lime dry building mixtures (DBM) synthesized calcium hydrosilicates [1, 2, 3].In order to expand the range of fillers to create calcareous composite knitting later the study on the development of technologies for synthesis of aluminosilicate fillers has been carried out [4, 5, 6, 7].

RESEARCH METHODS
Synthesis of aluminosilicates consisted of precipitation from solution of aluminum sulfate $Al_2(SO_4)_3$ with sodium silicate followed by washing the precipitate with water and drying out at a temperature of 100°C. In developing the technology for synthesizing aluminosilicate additives was investigated influence module waterglass, pH aluminum sulfate $Al_2(SO_4)_3$, the pH of the filtrate.

Analysis of the particle size distribution was made by an automatic laser diffractometer Fritsch Particle Sizer Analysette 22. The chemical and phase composition of the synthesized product was determined by X-ray station WorkStation (Thermo Scientific). X-ray diffraction spectra were obtained using $\lambda Co_{K\alpha 1,\ 2}$ radiation diffraction angles range 2θ=12-80°, scanning step 0, 02°.

Radiometric diagnostics was performed using PDF-2 database of the international centre for diffraction data (ICDD) using SearchMatch v.2. software. For unambiguous identification of chemicals we used classic full method of quantitative X-ray analysis using DDM ver program 1.95 c [8].

Structure data have been used in an international base of structural data (ICSD) for the modeling of mineral compositions. The concentration of the amorphous phase was definitely full profile XPA with internal calibration. The anatase used as a reference in the concentration of 30wt.%.

To determine the strength of the plastic or ultimate shear stress is applied cone rheometer KP-3. To do this in the system with certain interval immersed metal cone. Plastic strength (MPa) was calculated by the formula

$$\tau = K_\alpha \frac{F}{h_m^2} \qquad (1)$$

Where
F – tapered load, grams;
h_m-depth of immersion of the cone, cm.
K_α – constant of the cone.

DISCUSSION OF RESEARCH RESULTS
Synthetic aluminosilicates density of light gray powder of 568.151 kg/m3. Analysis of particle size distribution of the synthesized powder shows that less than 0.01% consists of particles with size of 0.010-0.500 mkm, content particle size of 100.000-200.000 mkm is 0.44%. Less than 5% consists of particles with a diameter of 3.226 mkm, less than 15%-the particle with a diameter 6.985 mkm. The value of the specific surface area is S=4950.44 cm^2/cm^3 (Table 1).

Table 1: Practical size distribution

The fraction, mkm	Content, %
0.01-0.5	0.01
0.5-2.0	1.81
2.0-3.0	2.55
3.0-4.0	2.8
4.0-5.0	2.73
5.0-10.0	12.61
10.0-20.0	16.61
20.0-45.0	27.2
45.0-80.0	29.14
80.0-100.0	4.09
100.0-200.0	0.44

When analyzing the modes of synthesis was found that when the pH of the solution of aluminum sulfate $Al_2(SO_4)_3$, pH≥5, the precipitate was not formed (Table 2).

Table 2: The output of the finished product

pH $Al_2(SO_4)_3$	Waterglass module	pH filtrate	Filler activity, mg/g	The output of the finished product, %.
5	2.69	-	-	-
3	2.69	9	≥350	41.9
1.5	2.69	9	≥350	38.9

5	2.88	-	-	-
3	2.88	9	≥350	34
1.5	2.88	9	≥350	42.9
5	2.69	-	-	-
3	2.69	5	≥350	40.48
1.5	2.69	5	≥350	44.76
5	2.88	-	-	-
3	2.88	5	≥350	33.12
1.5	2.88	5	≥350	45.87

The minimum output of the synthesized product is 33.12% at a of pH aluminum sulfate $Al_2(SO_4)_3$, equals pH=3 and the maximum yield (45.87%) – at a pH of aluminum sulfate $Al_2(SO_4)_3$, equals pH=1.5. Increase waterglass module with 2.69 to 2.88 leads to an increase in the output of finished products from 44.76% to 45.87%.

Specific surface area of the powder as determined by the BET method is $S=86.5 \pm 3.5\ m^2 / g$.

The chemical composition is shown in Table 3.

Table 3: Chemical composition

Chemical composition (wt.%)									
SiO_2	Al_2O_3	Na_2O	SO_3	TiO_2	Fe_2O_3	MgO	CaO	K_2O	∑
55.45	21.24	13.91	8.91	0.023	0.038	0.11	0.15	0.03	99.861

It was revealed that X-ray the synthesized powder is characterized by selective reflection and expression of a structured background ("diffuse halo"). Crystallized mass of the synthesized material presented thenardite-rhombic modification of sodium sulphate Na_2SO_4 (PDF 70-1541). In addition, the weak reflection on °=21, 29Θ2 was related to gibbsite (PDF 70-2038) [8].

Figure 1 shows the result calculating the concentration of crystalline phases.

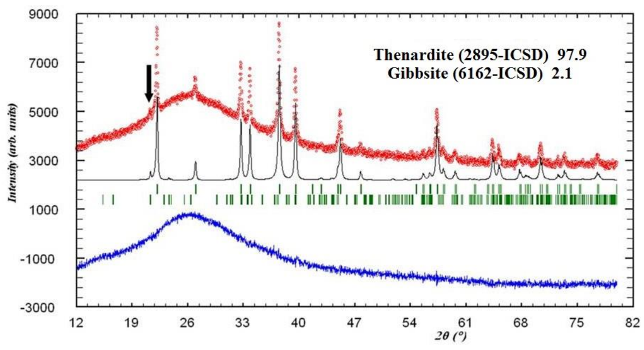

Figure 1: The calculation of the concentration of crystalline phases. The arrow indicated the reflection (002) of gibbsite

The amorphous phase is an aggregated nano-sized crystallites of similar cristobalite. The content of the amorphous phase was 77.5% (see figure 2).

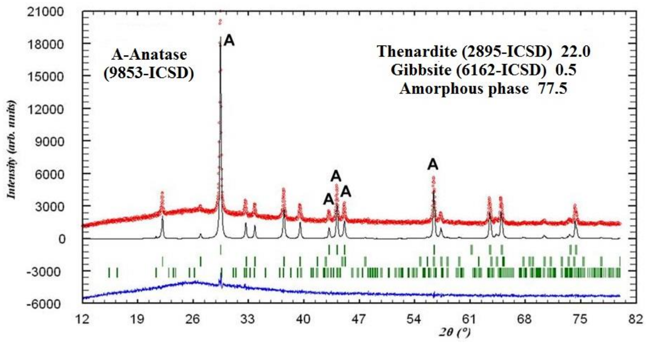

Figure 2: The calculation of the concentration of crystalline phases. The arrow indicated the reflection (002) of gibbsite.

Study patterns of influence the synthesized additives on the properties of the composites were made samples of lime grade 2 with an activity of 84.4%. additive content is 1-30% by weight of lime. The ratio of water to lime equal to W / L=1/1. The samples hardened in air-dry conditions at temperatures 18-20 and relative humidity of 60-70%.

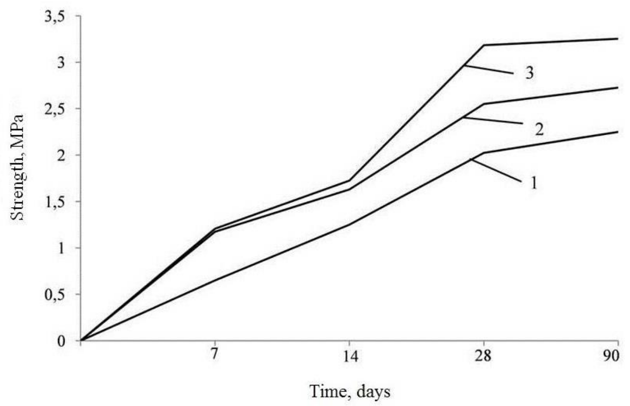

Figure 3: Measurement of the strength of the plastic lime putty when administered admixture 1-control composition (no addition); 2-content additives 5% by weight of lime; 3-additive content of 10% by weight of lime.

Analysis of the experimental data shows that the use of aluminum silicates, synthesized at pH of $Al_2(SO_4)_3$, aluminum sulfate solution, pH equal to 1.5, increases the compressive strength of lime samples aged 90 days of hardening at 27, 93-52, 72% compared with the samples based on the control formulations (without additives) (Figure 4). It was revealed that the amount of chemically bound lime in the control samples after 28 days of air-dry curing is 46.5%, and with the use of synthetic zeolites 50, 03-55, 28%. This demonstrates the high activity of the interaction of additives with lime, as evidenced by the amount of bound lime (see figure 4).

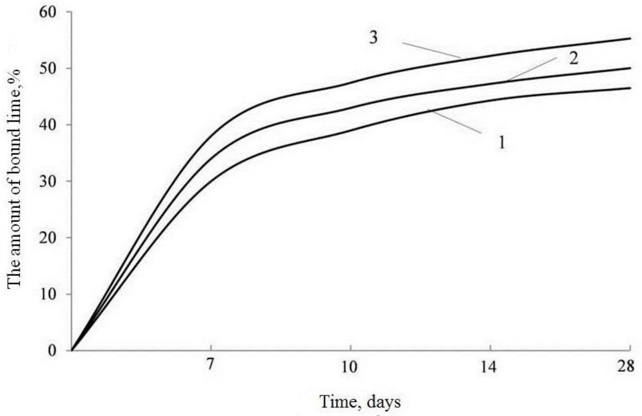

Figure 4: Change the amount of lime in the related process of hardening 1-control; 2-pH of the filtrate pH=9; 3-pH of the filtrate pH=5.

The research results indicate that the composite binder, consisting of lime and synthesized aluminosilicate in the amount of 10% by weight of lime, has a greater water resistance compared with hydrated lime. Thus, water resistance coefficient of samples prepared in the composite binder is K_r=0.68-0.71, water resistance coefficient of samples prepared on lime binder 0.31.

When evaluating the properties of mixtures with an additive synthesized aluminosilicates found that the introduction of additives leads to the synthesized set accelerating strength plastic.

Figure 5 shows the dependence of change of plastic strength lime putty when administered additive.

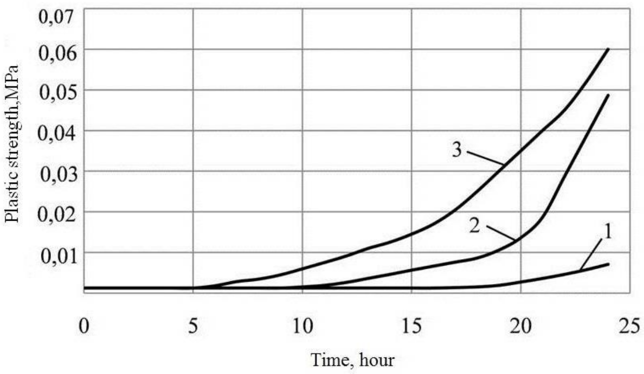

Figure 5: Measurement of the strength of the plastic lime putty when administered admixture 1-control composition (no addition); 2-content additives 5% by weight of lime; 3-additive content of 10% by weight of lime.

Plastogramm analysis (see figure 5) shows that the introduction of the aluminosilicate additive causes an earlier structure formationan of the limy test. Thus, the strength of plastic aged 10 hours after mixing is 0.0063 MPa when administered additive in an amount of 10% by weight lime (see Figure 5, curve 3) and at introducing an additive in an amount of 5%-0.0013 MPa (see figure 5, curve 2).

Based on the research we have developed a composition of dry construction mixtures. The composition is designed for finishing work. It contains hydrated lime, sand kvartsey, an additive based on amorphous aluminosilicate, a plasticizer Kratasol PFM and redispersible powder Neolit-4400. The finishing layer has the following properties:

Based on the studies developed part of the dry mortar designed for finishing work and containing hydrated lime, sand kvartsey, an additive based on amorphous aluminosilicate, a plasticizer Kratasol PFM and redispersible powder Neolit-4400. The finishing layer is developed on the basis of the mixture is as follows: adhesion strength=R_{adg} 0, 52 MPa, cohesive strength R_{kog}=0, 53 MPa,), water vapor permeability coefficient ·=0, 049 mg /(м·ч·Па), water absorption=10.45%, water resistance (softening coefficient) K_p=0, 68-0, 71.

To evaluate the crack resistance of the finishing layer on the basis of the developed formulations in the DBM investigated the state of stress of the coatings from the effects of temperature as one of the factors of aging. The calculation was made using software module SCAD Office. Constructive decision wall following: brickwork made of solid brick silicate (GOST 379) a density of 1800 kg / m^3 of cement-sand mortar, heat-insulating layer, a decorative finishing layer on the basis of the developed structure. As an insulation layer, we used plates made of foampolystyrene density 40 kg / m^3 and a thermal conductivity of 0.05 W / (m • 0C). Temperatures were determined by the thickness of the structure in accordance with the thermal calculations for different climatic conditions and humidity zones: city Moscow, Krasnodar, Novosibirsk.

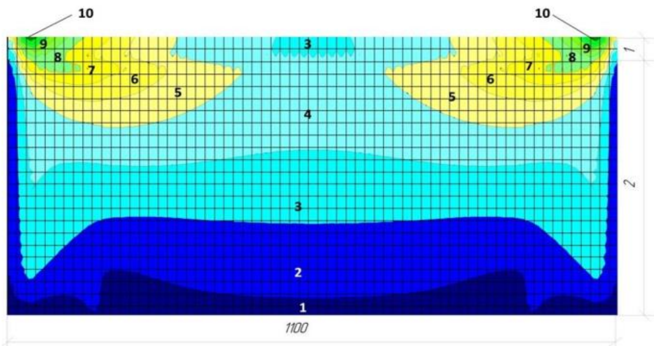

Figure 6: Stress concentration on the x-axis: 1 decorative finishing layer; 2-polystyrene. 1-(-0.0133)-(-0.0042) MP; 2-0, 0042-0, 013MPa; 3-0, 013-0, 0218MPa; 4-0, 0218-0, 0306MPa; 5-0, 0306-0, 0394 MPa; 6-0, 0394-0, 0482MPa; 7-0, 0482-0, 057MPa 8-0, 057-0, 0658MPa; 9-0, 0658-0, 101MPa; 10-0.101-0, 1098MPa.

Figure 6 shows the distribution of stresses over the length of the finishing and heat-insulating layer. Installed uneven distribution of stresses on thickness and length the finishing layer. The maximum voltage at the surface finishing layer constituting 0, 101-0, 1098MPa observed in the anchor location area.

Figure 7 shows the distribution of stresses in the X-axis in the month of April on the contact length of the finishing layer with a layer of insulation. The maximum voltage observed over a length of 500 mm (anchor zone) and make up to Krasnodar σ_x=0.0385 MPa, the Moscow σ_x=0.0503 MPa, Novosibirsk σ_x=0.061 MPa.

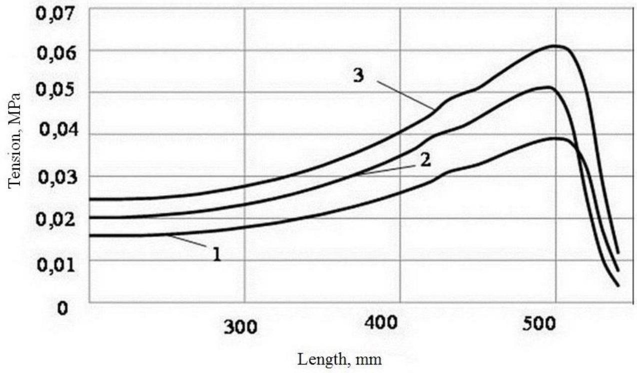

Figure 7: Dependence of tensile stresses hσ the contact length in April: 1 – Krasnodar; 2-Moscow; 3-Novosibirsk.

It was revealed that the maximum stresses in the coating are σ_x=(0, 101-0, 1098) MPa. They are less cohesive strength, R_{kog}=0, 53 MPa.

For adjusting the color gamut in a finishing coating composition proposed to incorporate pigments, wherein the pigment content is 1-5% by weight of lime. Pick up various color combinations of coatings, depending on the type of pigments.

Table 4 shows the processing and performance characteristics of the finishing composition and coatings.

Table 4: The technological and performance characteristics of finishing compositions and coatings

Characteristic	The characteristic value	
	designed	prototype
The average density of DBM, kg/m^3	1290-1304	1575
Coating density, kg / m^3	1470-1500	1650
The working lifey when stored in open containers, h	2-5	≥ 2
Workability	Good	Good
Recommended thickness of one layer, mm	20	20
Coveragerate of 10 mm thickness layer kg/m^2	12-14	15-17
Water retention, %	96, 0-97, 9	95, 0-97, 0
Drying time at 20 ° C until the degree of "5", min	Not more	Not more
Adhesive strength R_{adh}, MPa	0, 52±0, 025	0, 40
Compressive strength, R_{com}, MPa	2, 61±0, 163	0, 40
Coefficient of water vapor permeability	0, 049	0, 047
Cracks due to shrinkage	no	no
Application temperature, °C	5-35	5-35
Water resistance (softening coefficient)	0, 71	-

As a prototype selected lime plaster composition runit based on air lime, manufactured by LLC "Azhioproekt".

CONCLUSIONS

Thus, studies show the effectiveness of the use in lime compositions of the synthesized aluminosilicates as additives, the regulatory structure. Limy compositions using synthetic aluminosilicates characterized by good workability, the absence of cracking. Drying time to grade 5 is 15-20 minutes, the adhesion strength with the mortar substrate-0, 6-1, 2 MPa.

It is proposed to use a composite lime binder in the production of dry building mixtures intended for the restoration of buildings of historic buildings, as well as furnish the newly constructed facilities.

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