Influence of Synthesis Mode of Supplement Based on Calcium Hydrosylicates on the Structure and Properties of Lime Compositions

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Abstract. It was proposed to use synthesized calcium hydrosilicates in finishing lime dry mixes as a modifying supplement. The effect of substances containing amorphous silica which are used for synthesis on the activity of the modifying supplement was established. The effect of the synthesis mode of supplement on the structure formation of lime compositions was illustrated. It was found that the injection of supplements of hydrosilicates accelerates the increase of mechanical strength. The efficiency of the modifying supplements of amorphous silica, such as diatomite, in the synthesis was shown.

1. Introduction
Finishing coatings based on lime compositions have high rates of vapor permeability, adhesion strength and biostability. This allows them to be used for the restoration and finishing of buildings and structures of historical buildings [1-4].

Traditional materials that have been used for many years for the restoration of the facades of historic buildings were lime compositions. However, low operating durability of lime coatings leads to an increase in overhaul costs. An increase in the operational properties of lime coatings can be achieved by introducing into their formulation synthesized calcium hydrosilicates [5-8].

In previous studies, the effectiveness of adding modifying supplement based on calcium hydrosylicates (CHS) to the recipe of finishing lime dry mixes, which contribute to strength, water resistance, and frost resistance of finishing coatings, has been confirmed [9-12].

Synthesized calcium hydrosilicates are a mixture of low-basic and highly basic hydrosilicates. Taking into account that low-basic calcium hydrosilicates have higher strength [13-15], in the course of further studies in the synthesis of the modifying supplement, substances containing amorphous silica, in particular, the diatomite, were used.

2. Methods
Two CHS synthesis modes were used in work:
• mode 1 – the deposition in the presence of 15% CaCl2 solution in an amount of 50% by mass of soluble glass;
• mode 2 – the deposition in the presence of 10% CaCl2 solution in an amount of 50% by mass of soluble glass with the addition of diatomite, wherein the ratio of liquid:solid phase (L:S) was (L:S) = 1:2.

The resulting sediment was dried at a temperature of 100°C.
The synthesized supplements were used to develop the recipe of lime dry mix [16, 17, 18].

3. Results
The influence of synthesized modifying supplement on the structure formation of lime compositions was studied. The work used powder lime, cooked on lime of the second grade with an activity of 86%. The content of CHS additives was 30% of the weight of lime. For comparison, lime samples prepared using diatomite in an amount of 30% by weight of lime were made. Lime compositions with a water-lime ratio of W/L = 1.2 were prepared.

To estimate the structure formation of limes formulations with the use of GSK additives [19, 20], the amount of free CaO was determined during the hardening of lime samples. Figure 1 shows the data characterizing the change in free lime during hardening of lime samples.

It was found that lime samples based on HSC synthesized in the presence of diatomite are characterized by less free lime. In control samples at the age of 28 days of air-dry hardening, the amount of chemically free lime is 47.66% (Figure 1, curve 1). The amount of chemically free lime in lime samples based on the additive synthesized in the presence of diatomite is lower and is 25.23% (Figure 1, curve 4), while in calcined samples based on the addition of HSC synthesized without diatomite, 36.73% (Figure 1, curve 3).

The obtained data were further confirmed by differential thermal analysis (DTA) using the "Thermoscan-2" installation. Thermal analysis of lime samples was carried out in the temperature range 20-1000°C in an air atmosphere at a heating rate of 5°C/min. Figures 2, 3 show thermograms of lime samples.

Analysis of the thermograms of lime samples supplemented with calcium hydrosilicates synthesized in the presence of diatomite indicates that the thermal effect associated with the dehydration of portlandite is less and is Q = -4.18 J (Figure 3, curve 1) than for lime samples with the supplement, synthesized without diatomite, -10 J (Figure 2, curve 1). The thermal effect associated with the dehydration of portlandite of lime samples with diatomite is Q = -28.16 J (Figure 2, curve 2).

Thermal effects at a temperature of 800-1000°C characterize the dissociation of calcite in lime samples. Analysis of the thermograms revealed that the lowest thermal effect associated with calcite dissociation is limes samples with an additive based on calcium hydrosilicates synthesized in the
presence of diatomite, which is apparently associated with a lower content of calcite in their composition.

Figure 2. Curves of differential-thermal analysis of lime samples: 1- lime samples with an additive synthesized without diatomite; 2- control composition.

Figure 3. Curves of differential-thermal analysis of lime samples: 1- lime samples with an additive synthesized in the presence of diatomite; 2- lime samples with diatomite (without HSC).

Compression strength of lime samples aged 28 days air-dry hardening has been estimated. For comparison, lime samples were made only using diatomite in an amount of 30% by weight of lime.

It is found that the compression strength lime samples made with using calcium hydrosilicate supplement synthesized without diatomite is 4.7 MPa, while at the lime samples made with using calcium hydrosilicate supplement synthesized in the presence of diatomite - 7.59 MPa. Compression strength of control mix is 2.12 MPa.

4. Conclusions
Thus, the conducted studies testify to the effectiveness of the use of calcium hydrosilicates synthesized in the presence of diatomite in lime formulations as an additive regulating the structure formation, which will improve the properties of lime coatings. It is established that the mineralogical composition of lime samples based on the addition of calcium hydrosilicates synthesized in the presence of
diatomite contains more low-base calcium hydrosilicates and a smaller amount of portlandite and calcite.

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