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DRY CONSTRUCTION MIXTURES WITH COMPOSITE LIME ASTRINGENT

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ABSTRACT

The information about the technology of synthesis of filler based on calcium Hydrosilicates. The article provides information about the properties of dry construction mixtures prepared with a fine composite binder based on calcium hydrosilicates. It is shown that the use of lime composite binder in the formula of dry construction mixtures improves the operational stability of lime topcoat.

KEYWORDS: Dry Construction Mixtures, Resistance, Filler, Calcium Hydrosilicates

INTRODUCTION

Foreword

Dry construction mixtures (DCM) are widely used for the restoration of historic buildings and structures as well as facing newly constructed facilities. For many years, lime compounds have been traditionally used for these purposes. However, the low operational resistance of lime coating results in higher costs of maintenance and repair. In this regard, it becomes relevant to find a technological solution to increase the durability of coating based on dry lime mixtures.

As a working hypothesis, it is suggested that the inclusion of calcium hydrosilicates (CHS) in the known compositions should increase the resistance of the dry lime compositions. In order to obtain a filler on the basis of CHS, liquid sodium silicate glass with a different module, calcium chloride $CaCl_2$, was used in the experiment. In the production of the filler the following factors were taken into account: the density of liquid glass, the amount of non-solvent additive, the concentration of its solution, the mode of drying the sludge, and its storage time. It was revealed that the optimum density of sodium silicate component is ρ = 1130-1663 kg/m^3. The amount of additive $CaCl_2$ is calculated from the stoichiometric ratio; $CaCl_2$ was administered in the form of 7.5% and 15% solution [1,2].

It was found that the output of the filler synthesized from liquid glass in the presence of a 15% solution of $CaCl_2$ in an amount of 30 and 50% of liquid glass weight was 85%, and of the filler synthesized in the presence of 7.5% solution of $CaCl_2$ in an amount of 30% and 50% of liquid glass was 100%. After drying at 105°C the true density of the filler was 2200 kg/m^3, and the bulk density - 448 kg/m^3.

DISCUSSIONS OF RESULTS

The results obtained using an automatic laser diffractometer Fritsch Particle Sizer Analysette 22 indicate that the content of 0.05-10 micron-size particles is 18.35-24%, depending on the mode of synthesis.

The study of the qualitative composition of the newly synthesized filler with XRD, IR and electron microscopy revealed that the degree of crystallization of the samples is low [3, 4]. There formed calcium hydrosilicates of various basicity. The X-ray diffraction pattern (Figure 1) of the samples of the filler shows diffraction lines (Å) of calcium hydrosilicates CSH (I) and CSH (II): 10.13, 4.765, 3.582, 3.145, 2.875, 2.82, 2.719, 2.466, 2.283, 2.22, 2.062, 2.013, 1.823, 1.701, 1.629, 1.603, 1.41; calcite: 3.039, 1.921, 1.877, 1.66, 1.297, 1.262; and gidrogalites: 3.858, 3.26, 1.995.

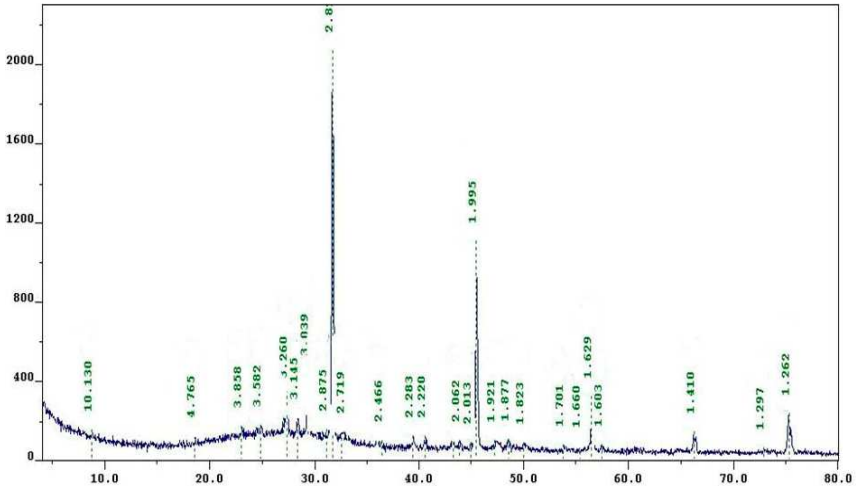

Figure 1: XRD Patterns of the Filler

The analysis of the images obtained with the electronic microscope scanner Phenom TM G2 pro (Figure 2) shows that the structure of the filler has the form of plate- and needle-like formations characteristic of hydrosilicate calcium.

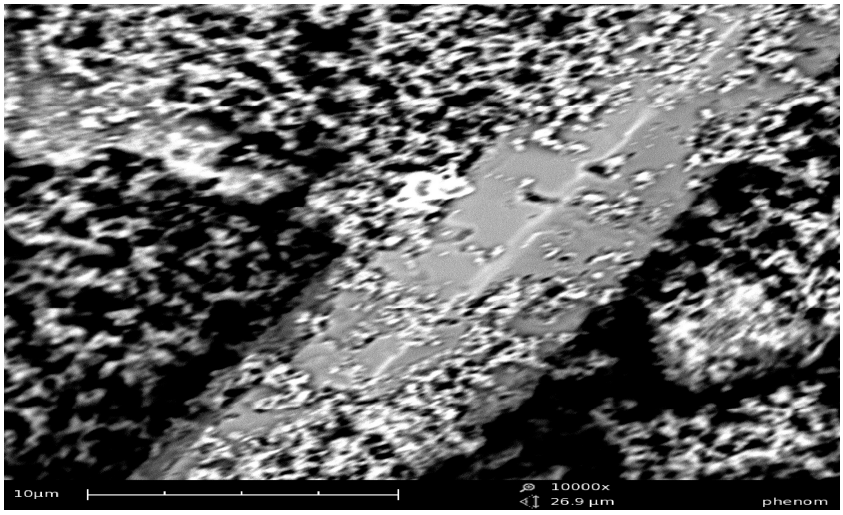

Figure 2: Electron Micrograph of the Powder × 10000

For additional evaluation, the analysis of the IR-spectrum of a sample of the obtained filler was conducted. Figure 3 shows clear absorption bands at 368 cm-1, 675 cm 1, 897cm-1, 981cm 1, 1278cm-1, 1635cm-1, 1 2450cm confirming the presence of calcium hydrosilicates CSH(I) and CSH(II) in the synthesized material. The absorption bands present on the IR-spectrum 712cm-1, 877cm, 1795cm-1 indicate calcite.

It was found that the storage of the filler in moisture-free conditions does not affect the activity of the filler. After 20 days of storage in moisture-free conditions, the reduction of the activity of the filler was 5%, and after the storage for 30 to 40 days it amounted to 8-20%.

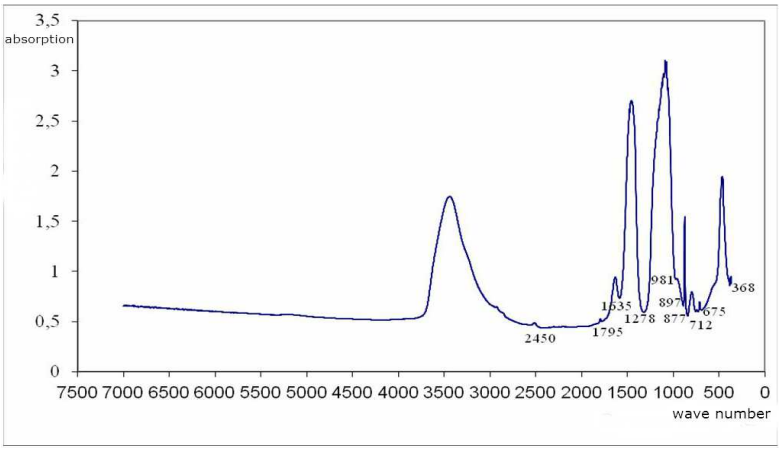

Figure 3: The IR Spectrum of the Sample Synthesized Filler

When developing the formula of the lime mixtures, the effect of the following variables on the properties of the coating mixtures were evaluated: the water--lime ratio, the amount of modifying additives and the CHS filler, and the production technology. The thermodynamic analysis of the possible reactions of the components in the mixture was carried out in accordance with the second law of thermodynamics. The results provide evidence of the probability of reactions between the filler and lime.

For the study of the solid-phase reactions occurring in the process of structure formation of calcareous compositions, a qualitative X-ray diffraction analysis using the Thermo Scientific diffractometer, model ARL X'TRA, was applied. The XRD analysis confirms the chemical interaction between the filler on the basis of CHS and lime. It was found that the amount of free lime in the samples without CHS after 28 days air-dry hardening was 60%, and in samples with the CHS filler it was 27%.

The data obtained was confirmed by differential thermal analysis. It was found that at the temperature range 400-700°C in the HSC limestone samples, along with the-decomposition of hydroxide and dissociation of calcite, there was observed dehydration of calcium hydrosilicates CSH(I) and CSH(II), which takes place at temperatures of 454.2°C, 471.2°C, 541.2°C, and 645.7°C, the products of which are γ and β calcium silicates, wollastonite and cristobalite (Figure 4).

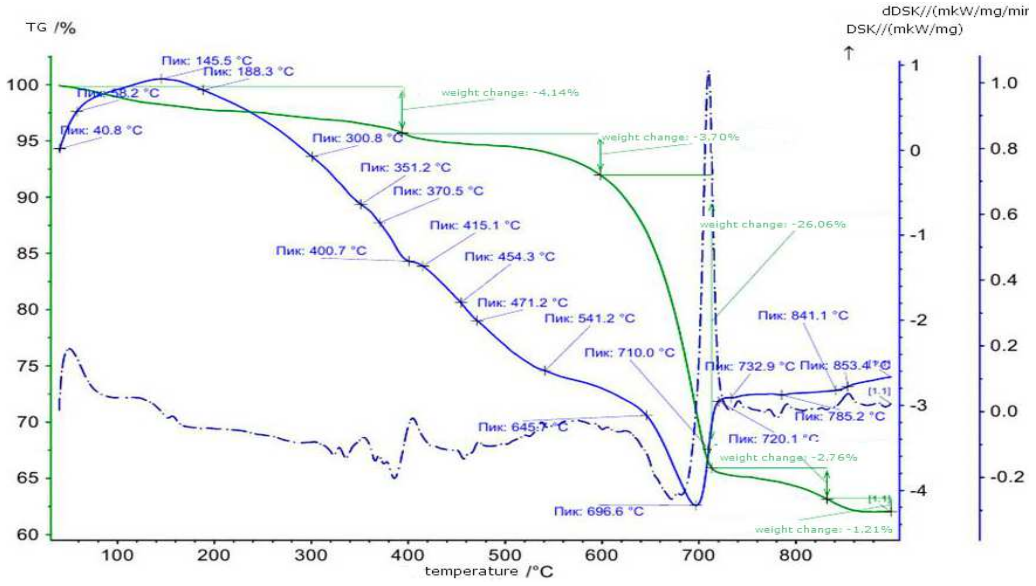

Figure 4: The Thermogram of Limestone Filled on the Basis of HSC

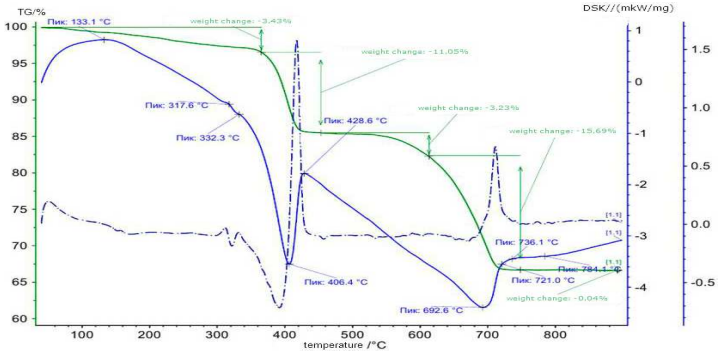

Figure 5: The Thermogram Control of Limestone

The total weight loss of the samples with limestone filler in this temperature range is 26%, while there was only a 5% weight loss in the experimental sample (without CHS) (see Figure 5). A significant loss of water by weight in limestone samples with the filler suggests that the chemical reaction of the filler and lime produces a large amount of highly basic calcium hydrosilicates. To improve the strength values of coating on the basis of DCM, redispersion powders were administered in the formula, Pulver DM 1142P and Neolith 7200, at 1% and 0.8% respectively of the weight of solids. It was found that the joint introduction of the redispersible powders, plasticizing additives, and the filler on the basis of CHS into the DCM formula results in an increase in compressive strength and adhesion, 4.12 MPa and 0.91 MPa respectively. The coatings based on these compositions are characterized by increased water resistance. The softening coefficient is 0.74.

To regulate the color in the facing coating, it is proposed to introduce into the composition pigments, wherein the pigment content is 1-5% of the weight of lime. A variety of colors are produced depending on the type of the coating pigment. To evaluate the operational stability of coatings based on lime DCM, some tests were conducted by alternating freezing and thawing of the finishing layer deposited on the cement-sand base. An assessment of the appearance of the coating was carried out in accordance with GOST 6992-68 "Paint coatings. The method of determining the stability of coating in atmospheric conditions". A "failure" was considered a condition of the coating, estimated as III.4 points. It was found that the painted samples withstood 50 cycles of tests, with the condition of the coating after 50 cycles of testing evaluated as V.5 points. Such condition is characterized by the loss of gloss up to 5%, a surface mesh visible to the naked eye of up to 5% of the surface, a slight change of color, no peeling, bubbles, defects or surface corrosion. Table 1 shows the values of the technological and operational properties of the developed DCM facing coating.

Table 1: Properties of the Developed DCM Compositions and the Facing Coating

Indicator	The Value of the Indicator of the Composition	The Value of the Prototype *
Compressive strength, Mpa	3-4	1-2,5
Adhesive strength $R_{сц}$, MPa	0,6-0,9	0,5-0,7
Frost, least n cycles	50	35
Drying time to degree "5" at (20 ± 2) º C, min	15…20	-
Water-holding capacity, %	98-99	97
Water absorption by weight, %	10-12	11-12
Water resistance	0,68-0,74	-
Shrinkage mm / m	0,26-0,34	-
Water vapor permeability μ, mg / m • h • Pa	0,05-0,07	0,07
Consumption of facing coating when applied in one layer, kg/m^2	1-1,2	1,4-1,6
Viability, an hour	1-1,5	2-3
Shelf life, months	6-12	6-12

Note. * Chosen as the prototype was lime plaster composition "Kreps Antique".

A normative document has been designed--the draft of the organization standards regulating the basic properties of the developed compositions. The testing of the results was carried out by "Spetsrabot" Ltd.

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