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DECORATIVE PLASTERS FOR FINISHING WORKS

Plasters for restoration and finishing works based on composite cements containing supplementary cementations materials of bright colors were developed. The peculiarities of formation of phase composition and microstructure of the cement matrix of decorative plasters were investigated.

Key words: modified composite cement, decorative plaster. supplementary cementitious materials.

Розроблено декоративні штукатурки для реставраційних та оздоблювальних робіт на основі композиційних цементів з вмістом додаткових цементуючих матеріалів світлих відтінків. Досліджено особливості формування фазового складу та мікроструктури цементної матриці декоративних штукатурок.

Ключові слова: модифікований композиційний цемент, декоративна штукатурка, додаткові цементуючі матеріали.

Introduction

During the last decades plasters remain such materials which are in great demand. Management of buildings in aggressive environment of urban development requires a complex scientific approach to the problems of research, production and use of new materials during restoration, decorating and finishing works. On the facades there are observed different kinds of damage, such as cracks, peeling of plaster and others. The most common reason for this is incorrectly selected particle size distribution of fine aggregate, high content of clay or silt impurities, excess of water and impaired production technology of plasters. Improvement of properties of plasters is achieved by use of composite cements containing supplementary materials of bright colors [1-3].

Therefore creation of composite cements through matching their average chemical composition by optimization of the content of white Portland cement, fine mineral supplements of light colors and fillers allows obtaining decorative plasters. These plasters provide designed strength, good adhesion to the base, improve quality parameters and are topical for use in restoration, decorative and finishing works [4-6].

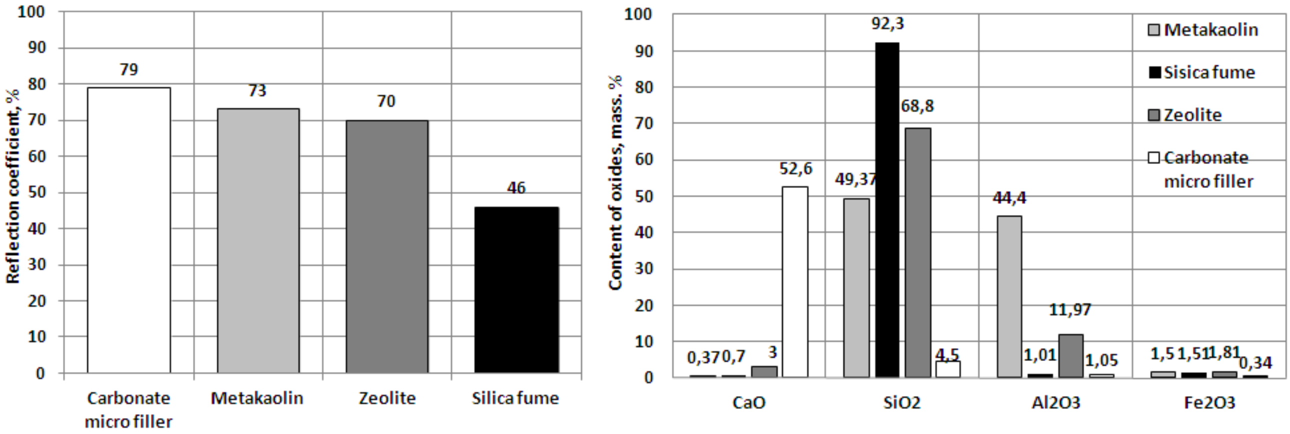
Materials and methods

To carry out the studies, white Portland cement CEM I 52.5 N "CIMSA" (Turkey) andCEM I of Ivano-Frankivsk plant were used. As mineral additives of light-colored, kaolin, metakaolin, zeolite, silica fume and carbonate microfiller were used. Admixture of sulfonaphthalene formaldehyde type was used as superplastisizer (SP).

Physical and mechanical tests of cements and decorative plasters were carried out according to usual procedures. Granulometry of cements and supplementary materials were established by use of laser diffraction particle size analyzer “Mastersizer 2000”. The morphology of cement paste surface and EDX were investigated with the help of scanning electron microscope Philips XL30 ESEM-FEG.

Results and discussion

The degree of whiteness for supplementary materials (Fig. 1, a) was established. Reflection coefficient for metakaolin and zeolite is respectively 73% and 70%. The highest reflection coefficient (79 %) is for carbonate microfiller. Chemical composition of supplementary materials and carbonate micro filler is shown on Fig. 1, b.



a *b*

Fig. 1. Degree of whiteness (a) and chemical composition (b) of supplementary materials

According to the particle size distribution of metakaolin (SSA=1580 m^2/kg) fractions Ø1; Ø10; Ø20 and Ø60 µm are respectively 21.6; 69.9; 79.9; 95.7 % and the grain size D10, D50 and D90 corresponds to 0.6; 3.8; 39.8 µm, whereas for silica fume (SSA=500 m^2/kg) content of fractions Ø1; Ø10; Ø20 and Ø60 µm are respectively 3.4; 33.0; 51.3; 88.9 % and the grain size D10, D50 and D90 corresponds to 3.5; 20.7; 63.4 µm.

Composite cements are obtained by mixing of white Portland cement CEM I 52.5 N, kaolin, metakaolin, zeolite, silica fume and carbonate microfiller in different proportions [7, 8]. For composite cement reflection coefficient is 71%, which can be attributed to class 3 (DSTU B V.2.7-257:2011) by the degree of whiteness. According to the particle size distribution of composite cement (SSA=840 m^2/kg), fractions Ø1; Ø10; Ø20 and Ø60 µm are respectively 8.0; 36.8; 52.2; 76.9 %, and the grain size D50 and D90 corresponds to 18.86; 111.0 µm.

By differential calorimetry analysis thermokinetic characteristics of composite cement were investigated. Duration of the induction period for composite cement is 1 h 20 min and the heat of hydration is 148.9 J/g. The heat of hydration of white Portland cement CEM I 52.5 is 288.8 J/g. A higher value of heat emission is associated by minerals C_3S and C_3A in the composition of white Portland cement.

Admixture of sulfonaphthalene formaldehyde type was used to obtain plasticized composite cements. Composite cement is characterized by flowability 140 mm (w/c=0.39) and refers to plasticized cements according to DSTU B V.2.7-46:2010, in this case technological effect is 21.7%. Due to the water-reducing effect, the rise of early strength is ensured and compression strength of binder f_{c28}=35.7 MPa is achieved. In tests made according to EN 196 (w/c=0.50), plasticizing effect is 30.6% and the strength after 7 and 28 days of hardening increases due to water-reducing effect and is respectively 28.7 and 41.8 MPa.

Mesostructure is of significant importance in the decorative plaster properties formation [9]. Most of building mortars are characterized by finely porous structure with partial filling of cavities between the grains of sand particles, which provides a wide range of building mortars with minimal cement amount and high content of air phase. Quartz sands with fineness modulus (M_f) 1.22 and 1.83 were used for production of plasters. Optimal density and cavity in loose and compacted condition of quartz sand is achieved when the ratio between two types of sand is $M_{f1.83}$:$M_{f1.22}$=80:20.

As can be seen from the Table 1 for plaster (amount of composite cement is 200 kg per 1 m^3 of sand) based on fine sand (M_f=1.22) with w/c=1.63, compressive strength after 7 and 28 days of hardening is respectively 2.1 and 3.6 MPa. When it is used optimized composition of quartz sand ($M_{f1.83}$:$M_{f1.22}$=80:20) in mortar, water demand decreases by 24%, and the compressive strength after 28 days of hardening increases by 1.7 times compared with a mortar based on fine sand.

Table 1

Physical and mechanical properties of plasters based on composite cement

Quartz sand ($M_{f1.83}$:$M_{f1.22}$)	w/c ratio	Flow-ability, mm	Density of mortar mixture, kg/m³	Flexural/compressive strength, MPa, at the age, days			Water absorption, %
				3	7	28	
0:100	1.63	210	1830	0.6/1.4	0.9/2.1	0.9/3.6	10.02
50:50	1.23	177	1836	0.6/1.3	0.7/2.0	1.0/4.9	9.13
80:20	1.23	178	1861	0.7/1.9	0.9/3.1	1.4/6.0	8.35
100:0	1.14	182	1903	0.6/1.7	0.8/3.0	1.2/5.6	7.95

Hardening of plasters based on plasticized composite cement is occurred as in the conditions of joint action of clinker minerals hydration and the reactions of chemical interaction of calcium hydroxide with supplementary cementitious materials in non-clinker part. Final products of composite cement hydration are ettringite (9.8 mass. %), negligible content of portlandite (0.6 mass. %), amorphous CSH phase (53.9 mass. %), the quantity of calcite and quartz makes respectively 23.6 and 5.5 mass. %. According to EDX, the relative content of elements in interpore space in the cement matrix of decorative plaster is characterized as CSH-phases (Fig. 2).

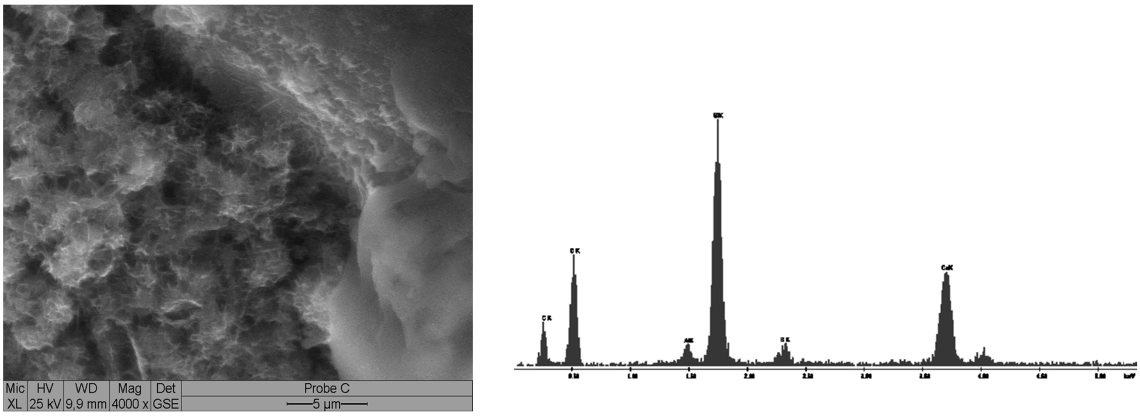
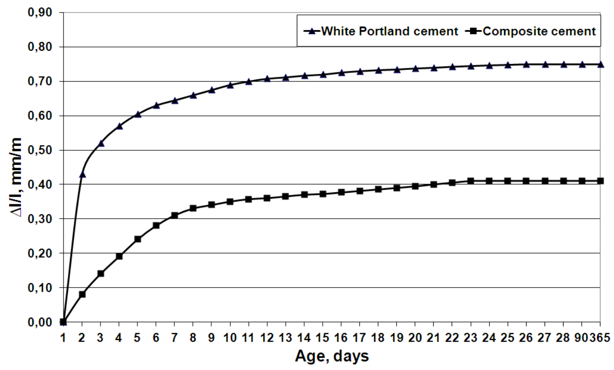


Fig. 2. The SEM images and the EDX spectrum of decorative plaster based on composite cement

Ettringite is formated through topochemical way that promotes the synthesis of the cement matrix strength in mortar. Fine particles of carbonate microfiller due to "fine powder" effect and chemical interaction with the products of hydration of alumo-containing phases with the formation of structurally active hexagonal AF_m-phases provides the synthesis of cement paste strength[6, 10].

For plaster without additives total porosity is 36.0% (open - 19.0%, closed - 17.0%), whereas for the modified decorative plaster total porosity increases up to 38.0%, but the ratio between open and closed porosity changes respectively to 15.5 and 22.5%. Use of modifiers reduces the coefficient of the average pore size, provides improved pore structure of the material, increases pore size uniformity ensuring finely porous structure. By the method of mercury porosimetry, it was established that decorative plaster is characterized by the largest pore volume (0.16 cm^3/g) with the pore size of 0.4 µm.

Shrinkage for plaster based on white Portland cement in air-dry conditions after 1 year of hardening is 0.75 mm/m, while for the decorative plaster based on composite cement it decreases to 0.41 mm/m (Fig. 3, a). As shown on Fig. 3, b, plaster based on white Portland cement CEM I 52.5 N is characterized by the lowest adhesion strength (R_{bf}=0.39 MPa). Adhesion strength for the decorative plaster based on composite cement is 0.58 MPa.



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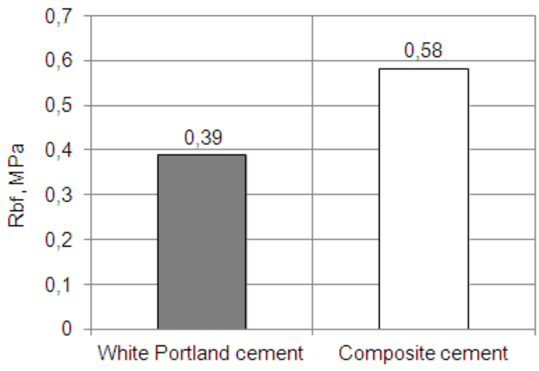

b

Fig. 3. Shrinkage (a) and adhesion strength (b) of plasters based on white Portland cement and composite cement

Decorative plasters are characterized by good frost resistance (50 cycles) and atmosphere resistance. By the method of low temperature dilatometry there were established that initial freezing temperature of the liquid phase of decorative plaster decreases from -2 to -6 ^{0}C, and its expansion deformation is 1.55 %.

Designed decorative plasters of light colors based on composite cement can be used as external plaster, which serves as decoration, characterized by sufficient moisture exchange between the plastered building elements and external environment, and when filling seams between the tiles on vertical and horizontal surfaces provides a complete decorative look of facing and restoration works.

Conclusion

Synergetic combination of supplementary materials of light colors, microfillers and polyfunctional admixtures in composite cement promotes the intensification of the structure formation processes and increases its mechanical properties. Physical and chemical modification of plaster by complex chemical admixture of plasticizing action allows obtaining of high-performance decorative plasters with improved quality parameters of mortars. Regulation of properties of composite cements by selecting and optimization of its components is the main direction to get and improve qualitative and technological characteristics of decorative plasters for finishing works.

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