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Mineral Additive Based on the Mixed-Layer Clays for Dry Construction Mixes

Valentina Ivanovna Loganina

Department of Quality management and technology of building production
«Penza State University of Architecture and Construction», Penza, Russia

Ludmila Viktorovna Makarova

Department of Quality management and technology of building production
«Penza State University of Architecture and Construction», Penza, Russia

Roman Viktorovich Tarasov

Department of Quality management and technology of building production
«Penza State University of Architecture and Construction», Penza, Russia

Elvira Rinatovna Akzhigitova

Department of Quality management and technology of building production
«Penza State University of Architecture and Construction», Penza, Russia

Abstract

Data about a mineral additive based on the mixed-layer clays, received as a result of low-temperature roasting are given. The regularities of influence of a mineral additive on structurization of limy composites are determined.

Keywords: mixed-layer clays, active mineral additive, low-temperature roasting, lime, structurization, dry construction mixes

1 Introduction

For restoration of historical building the broad application the limy dry construction mixes (DCM) are found. Finishing layers based on limy compositions have high rates of vapor permeability and bioproofness [1]. However limy coverings are characterized by low rates of strength, low durability. One of ways of prevention of premature destruction of limy finishing coverings is introduction in a compounding the modifying additives, in particular, metakaolinite. Metakaolinite at interaction with lime and water connects hydrate of oxide of calcium in hydroaluminate of calcium, that promotes the increase of strength and hydraulic properties of limy compositions [2, 3].

Considering limitation in resources of kaolinic clays and essential energy consumption on thermal processing of clay (to 800°C), the problem of development of the mineral additive, received on less power expensive technology based on local mixed-layer clays with prevalence of kaolinite is actual. According to data [4] at roasting clay in the range of temperatures 450-650°C one-water kaolinite $Al_2O_3 \cdot 2SiO_2 \cdot H_2O$ (hydraaluminium salt of metasilicon acid) which is more reactive in relation to lime, than metakaolinite is formed.

2 Experimental Study

Receiving of active mineral additives from the mixed-layer clays by their roasting at low temperatures is offered [5, 6].

In work clays of Vorobjevsky, Belinsky, Kameshkirsky and Lyagushovsky fields are applied. The analysis of mineralogical composition of clays allows to claim, that clay of the Vorobyevsky field belongs to kaolinite type of clays, Belinsky field – to hydromicaceous type, Kameshkirsky and Lyagushovsky fields – to montmorillonite.

For an assessment of change of energy condition of studied clays as a result of roasting distribution and concentration of the acid and basis centers on a surface of particles of clay was investigated. The method of adsorption of indicators with various values a pK_a was used. Quantitative definition of the centers of adsorption of this acid strength was carried out by a photometric method. Researches were made in area of the pentecosta acid (pK_a from 0 to 7) and the basis (pK_a from 7 to 13) the centers, and the luisovsk acid (pK_a >13) centers.

3 Results and Discussion

It is established that influence of a temperature factor led to change of energy condition of a surface of particles of studied clays. It is revealed, that number of pentecosta and luisovsk of the acid centers on a surface of thermally processed clays exceeds the number of the same centers on a surface of not burned clays.

In the field of acid pentecosta centers (pK_a from 0 to 7) the number of active centers on a surface of vorobjevsky clay burned at a temperature 450°C made 71, 17 mmol/g, while on a surface of not burned clay – 39, 54 mmol/g. In the field of the basis pentecosta centers (pK_a from 7 to 13) the number of the active centers on a surface of the clay burned at the same temperature made 8, 19 mmol/g, and on a surface of not burned clay – 1, 41 mmol/g. The increase of number of the active centers at pK_a > 13 on a surface of the burned clay, making 55, 36 mmol/g, while on a surface of not burned clay – 24, 6 mmol/g is observed (table 1).

Table 1: Influence of temperature of roasting of clay on energy condition (mmol/g) of its surface

Fields of clay	Temperature of clay roasting, ^oC	Field of acid and basis centeres (pK_a)		
		0-7	7-13	>13
Vorobjevsky	without roasting	39,14	1,41	24,60
	450	71,17	8,19	55,36
	500	51,23	1,41	43,06
	600	56,32	4,29	55,36
Kameshkirsky	without roasting	83,50	22,73	104,57
	400	87,70	36,85	413,65
	450	55,36	55,36	129,17
	600	135,24	38,36	104,57
Belinsky	without roasting	136,78	18,41	49,21
	450	106,03	30,80	92,26
	500	104,21	47,11	110,72
	600	123,23	110,72	86,15
Issinsky	without roasting	167,30	8,15	6,15
	400	206,87	32,26	24,09
	500	211,75	9,43	61,51
	600	167,49	13,12	43,06

Data about total of the active centers for concrete area of the acid and basis centers depending on temperature of roasting and a clay field are provided in table 2. Dehydration of a surface of layered aluminosilicates leads to formation of a large number of the centers of Lewis. So, before roasting in clay of Kameshkirsky field number of active centers in area $pK_a>13$ made 104,57 mmol/g, after roasting at a temperature of 400 ° C it made 413,65. Lewis's centers on a surface of clays give it large reactionary ability with the knitting. The greatest total number of the active centers have kameshkirsky, vorobyevsky, issinsky and belinsky clays after roasting at temperatures respectively 400°C, 450°C, 500°C and 500°C.

Table 2: Influence of temperature of roasting on total number of the active centers

Fields of clay	Temperature of roasting, °C	Total number of active centeres, mmol/g
Kameshkirsky	without roasting	210,8
	400	413,65
	450	216,96
	600	278,17
Vorobjevsky	without roasting	65,55
	450	134,72
	500	95,7
	600	115,97
Belinsky	without roasting	204,398
	450	229,09
	500	262,04
	600	218,89
Issinsky	without roasting	181,60
	400	263,22
	500	282,69
	600	223,67

The offered mineral additive received at low-temperature roasting, was applied at developing a compounding of limy dry construction mixes [7]. Roasting of clays was carried out at a temperature 500°C. As small filler the Ukhta quartz sand of fractions 0,63 - 0,315 mm and 0,315 - 0,16 mm in the ratio 80:20 was applied.

The analysis of experimental data (figure 1) testifies, that the greatest durability at compression is reached at introduction in composition the DCM mineral additive in number of 10% of the mass of lime.

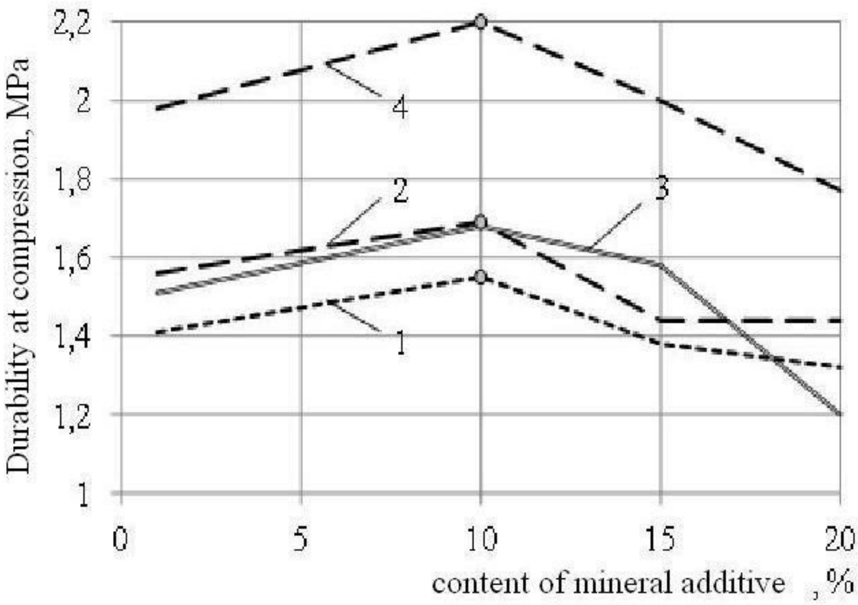

Figure 1: Change of durability of a limy composite depending on concentration of a mineral additive based on clays of fields:

1 – Vorobyevsky; 2 – Kameshkirsky; 3 – Issinsky; 4 – Belinsky

So, at addition in a compounding of the DCM of vorobyevsky clay after roasting at a temperature of 500 ° C in number of 10%, durability at compression Rc made 1,55 MPas, in number of 15% - 1,38 MPas, in number of 20% - 1,32 MPas. Similar regularity is observed also at introduction of mineral additives based on the Belinsky, Issinsky and Kameshkirsky clays. Possibly, it connected with a fact, that at increase of quantity of a mineral additive more than 10% turn out surplus of fine fraction, that leads to a lack of water of mixing.

Experimental data (table 3) show, that introduction in limy and sand composition the burned clay promotes to increase of durability at compression at the age of 28 days of air and dry curing depending on temperature of roasting and a type of clay by 2,0-2,6 times. At introduction of Kameshkirsky clay the greatest value of durability at compression at the age of 28 days of curing is reached at introduction to construction of additive, burned at a temperature 400°C and makes Rc =1,75 MPas, while at composition without additive - 0,84 MPas. At introduction of Vorobyevsky clay, burned at a temperature of 450 ° C, durability increases to 1,67 MPas. Introduction of Belinsky and Issinsky clays after roasting at a temperature 500°C promotes to increase of durability of compositions to 2,2 and 1,68 MPas respectively.

Table 3: Influence of temperature of roasting on value of durability at compression of Rc, MPa

Fields of clay	without additive	With additive of clay without roasting	Temperature of roasting, ^oC				
			400	450	500	550	600
Kameshkirsky	0,84	1,22	1,75	1,70	1,69	1,63	1,58
Vorobjevsky		0,95	1,28	1,67	1,55	1,52	1,5
Belinsky		1,31	1,62	1,71	2,2	1,98	1,78
Issinsky		0,95	1,45	1,57	1,68	1,64	1,58

Results of the conducted researches confirm, that addition in limy and sand composition of low-roasting clay promotes to increase the durability of limy composites at 6-26% in comparison with metakaolinite.

In addition for an assessment of structurization of limy and sand compositions with addition of a mineral additive the kinetics of binding of lime was investigated. The analysis of experimental data testifies, that reduction of amount of free lime is observed eventually. So, at the age of 7 days the amount of free lime in limy and sand composition makes 84,5%, and at the age of 28 days makes78,6%. The smaller content of amount of free lime in compositions with use of clay after roasting at a temperature of 500 ° C is established. So, in samples with addition of Belinsky and Kameshkirsky clays, burned at this temperature, the content of free lime decreased by the 28th days of curing to 68,2% and 70,83% respectively.

4 Conclusion

By results of the conducted researches the compounding of DCM, containing hydrated lime, quartz sand of fractions 0,63-0,315 mm and 0,315 - 0,16 mm in the ratio 80:20 – 77,35; Vorobyevsky clay after roasting at t = 450°C – 1,93; supersoftener C - 3 – 0,19; redispersible powder Mowilith Pulver DM 1142 P - 0,99 is developed. The main properties of developed DCM are given in table 4.

Table 4: Technological and operational properties of finishing compositions

Name of indicator	Value of indicator of Finishing compositions
Average density DCM, ρ_a, kg/m^3	1290-1304
Viability at stored in open capacities, hour	8-10
Workability	good
Recommended thickness of one layer, mm	to 20
Consumption of finishing composition at 1 layer is applied of thickness 10 mm, kg/m^2	12-14
Water-holding capacity, %	98,0-98,3
Time of drying at 20 ^{o}C to degree «5», min	no more 55
Adhesive durability $R_{аг}$, MPa	0,60-0,76
Durability at compression, R_c, MPa	2,52-3,71
Shrinkable deformations, ε, %	0,027-0,034
Vapor cofficient μ, mg/m·h·Pa	0,055-0,058
Cracks due to shrinkage	no
Temperature of application, ^{o}C	5-35

It is established, that on technological and operational properties the developed dry mix conforms to requirements of DIN 18550 and the Russian normative documents.

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