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MICRO- AND NANODISPERSED ADDITIONS IN WOOD-AND-CEMENT COMPOSITIONS

Introduction

Nowadays the main trend in the development of construction materials and units production is the wide utilization of recycled industrial waste and wood waste among them. It is connected with limited raw materials, necessity of long-distance transportation of raw materials, high material and energy output of some technological processes of extraction and processing of raw materials, which hold back the development of construction materials industry on the basis of raw materials.

Obtaining of wood-and-cement compositions (WCC) as ecologically safe, for human health, materials on the basis of logging and wood-processing factories waste will allow to preserve lands because there is no necessity for their utilization and allotment sites for earth boards. It also helps to decrease pollution of the environment with industrial waste.

1. Experimental part

The purpose of the work was the investigation of influence of micro- and nano-dispersed additions on physical and technical properties of wood-and-cement compositions.

As a microaggregate it was decided to use microsilica and as nanodispersed additions - additions with nanosized particles of schungite and silica.

As an organic aggregate logging and wood-processing industry waste - sawdust of coniferous and deciduous species of trees were used. Fractional composition of wood waste corresponded to the demands of GOST 19222 (state standard). Humidity, when drying wood waste in the kiln at the temperature of 35°C was 9.89%, poured density - 95 kg/m^3.

As a binding substance Portland cement M 500 D0 was used. It corresponds to the demands of GOST 10178 and GOST 22266, which specify binding substances for producing wood cement. Microsilica was introduced into the mixture together with cement in the amount from 3 up to 100% from cement mass. Additions with nanosized particles of silica and schungite were introduced into the mixture together with the water for dissolving in the amount (in the terms of dry substance) from 1.43 up to 9.61% and from 0.14 up to 0.96%, respectively. Such physical and technical indices as average density, coefficient of thermal conductivity, limit of density under compression and water absorption were determined. Besides the influence of complex usage of microsilica and additions with nanodispersed particles were investigated:

– wood-and-cement compositions with the content of 50% of microsilica and from 0.14 up to 0.96% of the addition with nanosized particles of schungite;
– wood-and-cement compositions with the content of 10% of microsilica and from 1.43 up to 9.61% of the addition with nanosized particles of silica;
– wood-and-cement compositions with the content of 2.87% of the addition with nanosized particles of silica and from 5 up to 30% of microsilica;
– microstructural investigations of patterns were conducted with using programme and apparatus complex which includes raster electron microscope Quanta 200 3D connected with personal computer.

2. Results and discussion

Diagrams presented in Figure 1 were drawn on the basis of the obtained data of the influence of microsilica content on physical and technical properties of wood-and-cement compositions.

So the introduction of the microsilica in the amount of 3% (from cement mass) allows to increase the limit of strength under compression 4.5 times in comparison with the control WCC and the averaged density, by this, decreases 1.3 times. Increase of microdispersed addition content up to 20% results in growth of strength in 31.3 times, and the average density corresponds to the density of wood-and-cement composition without microsilica and makes 744 kg/m^3. Further increase of addition content decreases the limit of density at compression from 7.42 up to 1.02 MPa.

If the content of microsilica in the amount of 30 and 40% the average density is 848.9 and 931 kg/m^3 under further increase of addition content the decrease of average density up to 650.8 kg/m^3 is observed.

Water absorption of wood-and-cement composition when introducing the addition (in the amount of 3%) in its structure increases in comparison with the control structure. At increase of the microsilica content from 6 up to 40% the decrease of water absorption from 93 up to 20.1 is observed.

The change of thermal conductivity coefficient, when introducing microsilica into the structure of wood-and-cement composition, the same change of average density takes place.

Microsilica has the similar effect on properties of wood-and-cement composition because its high activity is defined by presence of silica dioxide of amorphous modification and presence of ultradispersed particles of spherical form.

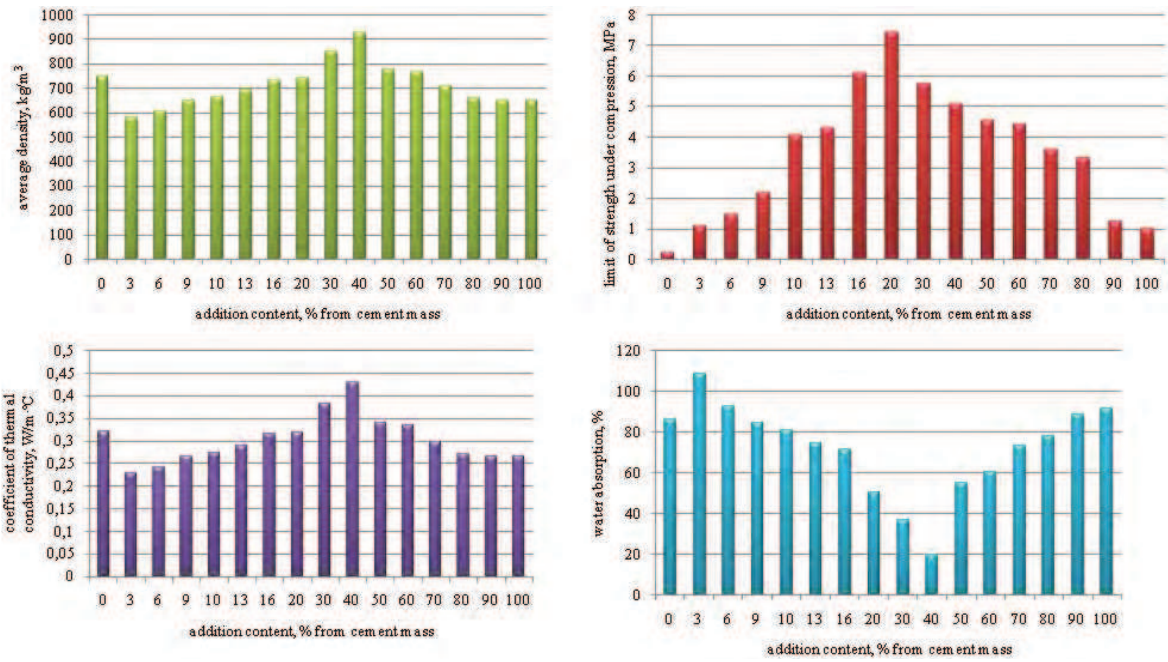

Fig. 1. Diagrams of dependence of physical and technical characteristics of WCC from the quantity of microsilica

Usage of additions with nanosized particles of silica makes for their ability to interact with calcium hydrosilicate forming sparingly soluble mixed salts which close pores.

Results of the tests of WCC with the use of additions with nanosized particles are given in Table 1.

The use of the addition with nanosized particles of schungite in the amount of 0.14% (in the terms of dry substance) results in decrease of average density in 11%, coefficient of thermal conductivity in 15%, and, by this, the limit of strength under compression increases in 22.5%.When further increasing addition content the decrease of average density is observed and, accordingly, the coefficient of thermal conductivity. So when introducing 0.96% of the addition into the structure of WCC the average density decreases in 22%, and coefficient of thermal conductivity in 30%. When using the addition in the amount of 0.43% the limit of strength under compression WCC increases in 33.6%, at further increase of the addition from 0.62 up to 0.96%, the decrease of strength is observed.

Water absorption of wood-and-cement compositions when introducing additions with nanosized particles of schungite in the amount from 0.14 up to 0.43%

results in decreasing of water absorption in 4÷6%. At further increase of addition content the growth of water absorption is observed. When using the last one in the amount of 0.96% the meaning of water absorption of modified WCC exceeded the meaning of control patterns in 26%.

TABLE 1

Results of the tests of wood-and-cement compositions with the use of nanosized particles additions

Number of structure	Consumption of addition [%] (in terms of dry substance)	ρ_o [kg/m^3]	λ [W/m·°C]	$R_{compr.}$ [MPa]	W_m [%]
1	0	743	0.322	0.24	86.5
Addition with nanosized particles of schungite					
2	0.14	665	0.274	0.31	83.0
3	0.29	662	0.273	0.36	82.5
4	0.43	651	0.266	0.36	81.3
5	0.62	651	0.266	0.31	84.8
6	0.77	637	0.258	0.25	93.3
7	0.96	580	0.226	0.20	117.1
Addition with nanosized particles of silica					
8	1.43	712	0.302	1.86	49.2
9	2.87	715	0.303	2.10	47.4
10	4.30	734	0.314	2.49	46.9
11	6.22	745	0.321	2.70	45.9
12	7.70	757	0.328	2.76	44.1
13	9.61	759	0.329	3.15	43.5

Introducing the addition with nanosized particles of silica in the amount of 1.43% into the structure of composition results in increasing the limit of strength under compression (in comparison with control structure) in 87%. By this the decrease of average density, coefficient of thermal conductivity and water absorption in 5, 6 and 43%, respectively, is observed. At the increase of addition content up to 9.61% minor growth of average density (1.6%) takes place, and so the coefficient of thermal conductivity (2.1%).

The limit of strength under compression when introducing up to 9.61% of the addition into WCC structure results in increasing the limit of strength under compression in 92.5% in comparison with control structure and in 41% in comparison with the wood-and-cement composition, in the structure of which 1.43% of the addition with nanosized particles of silica was introduced.

Increasing the content of the addition with nanosized particles of silica up to 9.61% ,water absorption decreases in 49.7% in comparison with control structure, and in 12% in comparison with the wood-and-cement composition, in the structure of which only 1.43% of the addition was introduced.

Investigation results of influence of complex use of microsilica and additions with nanodispersed particles are given in Table 2.

TABLE 2

Results of tests with wood-and-cement compositions with the use of microaggregates and nanoadditions

Number of structure	Consumption of addition [%] (in terms of dry substance)	ρ_o [kg/m^3]	λ [W/m·°C]	$R_{compr.}$ [MPa]	W_m [%]
1	0	743	0.322	0.24	86.5
Microsilica (50% from cement mass) and addition with nanosized particles of schungite					
2	0.14	877.2	0.399	7.86	26.1
3	0.29	905.5	0.416	8.67	16.7
4	0.43	962.1	0.450	11.01	14.6
5	0.62	707.4	0.299	2.703	27.0
6	0.77	792.3	0.349	3.774	27.8
7	0.96	735.7	0.315	3.825	33.7
Microsilica (10% from cement mass) and addition with nanosized particles of silica					
8	1.43	670.6	0.278	3.52	65.3
9	2.87	702.6	0.296	5.30	66.4
10	4.30	712.2	0.302	4.12	67.9
11	6.22	711.6	0.301	3.67	66.6
12	7.70	699.8	0.295	2.05	63.5
13	9.61	688.4	0.288	1.38	60.8
Addition with nanosized particles of silica (2.78% in terms of dry substance) and microsilica					
14	5	690.4	0.249	2.99	70
15	10	610.4	0.243	5.71	65.5
16	15	610.4	0.243	6.24	62.6
17	20	756.4	0.328	10.35	62.2
18	25	764.0	0.332	10.68	58.6
19	30	825.4	0.368	14.7	49.1

Investigations showed that under joint usage of microsilica in the amount of 50% and the addition with nanosized particles of schungite in the amount of 0.14% (in the terms of dry substance), the limit of strength under compression increases in 97% in comparison with control patterns. By this, the average density and coefficient of thermal conductivity increases in 15 and 19%, respectively, and water absorption decreases in 70%.

The usage of the addition with nanosized particles of schungite in the amount of 0.43% together with microsilica (50%) greatly influenced the properties of wood-and-cement composition. Water absorption decreased in 83% in comparison with control patterns. The limit of strength under compression increased in 98%. Average density and coefficient of thermal conductivity increased in 22 and 28% respectively.

When introducing 10% microsilica and addition with nanosized particles of silica in the amount of 2.78% from cement mass into the structure of wood-and-cement composition, the growth of strength under compression from 3.52 up to 5.30 MPa takes place. At further increase of content of the addition with nanosized particles of silica up to 9.61% the strength decreases up to 1.38 MPa.

Average density and coefficient of thermal conductivity by this change in the following way:

– with the content of the addition with nanosized particles of silica from 1.43 up to 4.30% we observe the increase of average density in 6% in comparison with the patterns, in which content 1.43% of the addition with nanosized particles of silica was introduced, coefficient of thermal conductivity in 8%, water absorption, by this, increased in 4%;
– at the increase of the content of the addition with nanosized particles of silica from 6.22 up to 9.61% we observe the decrease of average density in 4%, in comparison with patterns, in which content 6.22% of the addition with nanosized particles of silica was introduced, coefficient of thermal conductivity in 5%, water absorption decreased in 11%. At the complex usage of microsilica in the amount of 10% from the cement mass and the addition with nanodispersed particles of silica, the optimal content of the last one was 2.87%.

a) b)

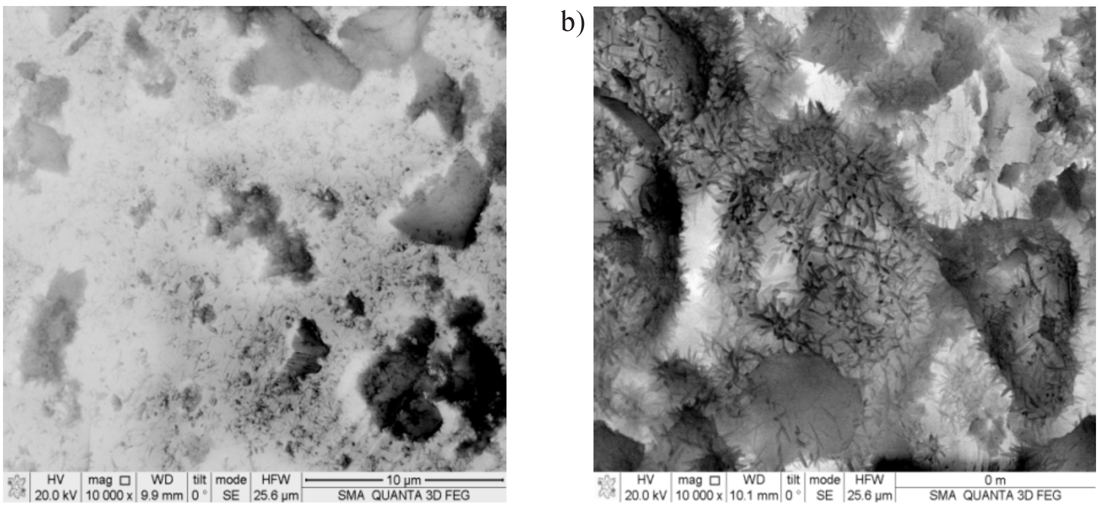

Fig. 2. Microstructure of WCC: a) control pattern, b) pattern with microaggregate and the addition with nanosized particles of silica

Introducing the addition with nanosized particles of silica in the amount of 2.87% and microsilica in the amount from 5 up to 30% into the wood-and-cement composition has led to increasing the limit of strength under compression in 98%. Here we observe the decrease of water absorption from 70 up to 49.1%. Average density and coefficient of thermal conductivity grow with the increase of the microsilica content. So average density increases from 690 up to 825 kg/m^3, and coefficient of thermal conductivity - from 0.243 up to 0.368 W/m·°C.

Figure 2 presents the microstructure of the control pattern and the pattern with microaggregate and the addition with nanosized particles of silica. In the picture it is clearly seen that at complex use of both microaggregate and addition with nanosized particles calcium hydrosilicates are forming on the surface of organic aggregate in the shape of needled new formations.

Conclusion

Thus, complex use of additions with nanosized particles and microsilica, as a microaggregate allows to regulate the structure of the material at micro- and nanolevel at the expense of formation of sparingly soluble mixed salts filling pores of wood-and-cement compositions,that is confirmed by x-ray analyses, providing, thereby, obtaining of wood-and-cement compositions with the limit of strength under compression in 62 times exceeding the meaning of strength limit under compression of control patterns.

References

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Abstract

Problems of obtaining wood-and-cement compositions with improved physical and technical indices when introducing micro- and nanodispersed additions into the structure of composition are studied.

Keywords: wood-and-cement compositions, microsilica, addition with nanosized particles of silica, addition with nanosized particles of schungite

Mikro- i nanodyspersyjne dodatki w kompozytach wiórowo-cementowych

Streszczenie

Analizowano problemy związane z uzyskaniem kompozytu wiórowo-cementowego oraz poprawą jego wskaźników fizycznych i technicznych podczas wprowadzania dodatków mikro- i nanodyspersyjnych uzupełniających strukturę kompozytu.

Słowa kluczowe: kompozyty wiórowo-cementowe, pył krzemionkowy, dodatek z nanocząsteczkami krzemowymi, dodatek z nanocząsteczkami szungitowymi