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EFFICIENCY OF THE APPLICATION OF A COMPLEX MODIFIER IN THE COMPOSITION OF GYPSUM BINDERS

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The article presents the results of the study of the physical and mechanical properties of modified gypsum binders by the complex use of water preparation sludge, dolomite flour and plasticizer. It is shown that the modification of gypsum binders contributes to the increase in their strength characteristics.

Building materials based on gypsum raw materials are characterized by low energy consumption during their production and the best environmental performance compared to other materials of similar purpose. The actual direction of the study, which will allow to expand the range and scope of materials based on gypsum binders, is to increase their physical-mechanical characteristics [1].

The studies aimed to study the feasibility of effective use sludge of water treatment of Novopolotsk HES as a modifier of gypsum binder are of practical interest. The chemical composition of the sludge of water treatment is shown in table 1.

Table 1. – Chemical composition of sludge of water treatment of Novopolotsk HES

$CaCO_3$	3MgCO*MgOH*2H_2O	$CaSO_4$x2H_2O	$Fe(OH)_3$	SiO_2	$CaSiO_3$	Organic compounds
62,8 - 68,2%	5,8 – 10,6%	3 – 9,5%	4,1 – 6,7%	0,5 – 4,7%	3,9 – 6,6%	4,9 – 8,9%

Analysis of the chemical composition shows that the main compound contained in the sludge is calcium carbonate (62.8 – 68.2%). For the experiments, the sludge was dried in a drying cabinet of the brand «SNOL 58/350» for 5 hours to constant weight at a temperature of 110 °C. The dried sludge, after cooling, was ground in an DIM drum mill and sieved on a MS mechanical sieve. The fraction of the sludge passed through the № 008 sieve was used. The value of the true density of the sludge of water treatment was determined according to GOST 8735 [2] and it was 2170 kg/m^3. The bulk density corresponds to STB EN 1097-3 [3] and was 780 kg/m^3.

Dolomitic flour produced by OS «Dolomit», which corresponds in its characteristics to GOST 14050 [4], was also considered as a modifier. Superplasticizer «Stakhement 2000M Zh30» was used as a plasticizing additive, the mass fraction of dry substances in the superplasticizer is 30%. The concentration of hydrogen ions (pH) is 6.

The method of mathematical planning of the experiment based on a three-factor plan of the second order was used to determine the optimal number of components of the complex modifier of the gypsum binder. The following factors were considered as variable factors: the mass of gypsum binder sludge of water treatment (x_1), plasticizer «Stakhement 2000M Zh30» (x_2) and dolomite flour (x_3), and the compressive strength, bending strength of gypsum stone. Factors and intervals of their variation are presented in table 2.

Table 2. – Factors and intervals of their variation

	Lower level (-1)	Main level (0)	Upper level (+1)	Variation interval	The name of the factor
x_1	1	2	3	1	Sludge of water treatment
x_2	0,1	0,2	0,3	0,1	Stakhement 2000M Zh30
x_3	5	10	15	5	Dolomite flour

For carrying out experimental studies, the gypsum building «Taifyn Master » N 35, type G-5 III A, produced by LLC «Taifyn», was used. The determination of the physical mechanical characteristics of the modified gypsum binder was carried out on samples of beams 40×40×160 mm. The test samples were carried out 2 hours after molding in accordance with GOST 23789 [5] on a hydraulic press brand PGM – 500 MG 4A.

The experiment planning matrix in coded and natural variables and the results of the studies performed are presented in table 3.

Table 3. – Planning Matrix and Experiment Results

Experience number (u)	Planning matrix			Natural values of variables			Output parameter – strength, MPa	
							Bending	In compression
	x_1	x_2	x_3	Sludge of water treat-ment	Stakhe-ment 2000M Zh30	Dolomi te flour	y_1	y_2
1	-1	-1	-1	1	0,1	5	2,3	5,7
2	+1	-1	-1	3	0,1	5	2,5	4,6
3	-1	+1	-1	1	0,3	5	3,6	6,3
4	-1	-1	+1	1	0,1	15	3,0	5,1
5	-1	0,19	0,19	1	0,219	10,95	3,5	5,7
6	0,19	-1	0,19	2,19	0,1	10,95	3,0	6,2
7	0,19	0,19	-1	2,19	0,219	5	4,1	8,2
8	-0,29	+1	+1	1,71	0,3	15	2,9	5,7
9	+1	-0,29	+1	3	0,171	15	3,3	5,9
10	+1	+1	-0,29	3	0,3	8,55	3,7	6,7

After carrying out mathematical processing of the experimental data, it was found that the extremum of the response function is within the limits of variation of the variable factors. The extremum value is y_1 opt = 3.881 MPa, y_2 opt = 7.651 MPa. The extremum of the response function corresponds to the values of the factors: x_1 (sludge of water treatment) = 2.252 (% by weight of the gypsum binder) and x_2 (Stakhement 2000M Zh30) = 0.227 (% by weight of the gypsum binder) at x_3 (dolomite flour) = 10 (% by weight gypsum). For further research, control samples were made without a modifier (composition 1) and samples with the optimum content of the components of the complex modifier (composition 2). The results of studies to determine the physicomechanical properties of the gypsum binder are shown in table 4.

Table 4. – Physical and mechanical properties of the modified gypsum binder

Normal density	Density, kg/m³	Setting time, min		Water absorption, %	Total porosity, %	Strength, MPa (%)	
		Start	End			Bending	In comp-ression
0,46	1672	6	15	5,0	8,36	2,5 (100)	5,5 (100)
0,48	1681	6	14	6,1	10,3	3,6 (144)	7,7 (140)

Analysis of the obtained results shows that the use of the complex modifier of the properties of the gypsum binder can increase the flexural and compressive strength by 44 and 40%, respectively. At the same time there is a decrease in the density of the gypsum stone by 0.5%. The end of the setting time was 1 minute less compared to the control. Thus, the modification of the gypsum binder complex additive on the basis sludge of water treatment, dolomite flour and plasticizing additive allows to increase the strength properties and reduce the density of the gypsum stone.

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