UDC 691.263.5

EFFECTIVE MODIFIERS OF GYPSUM BINDERS SUBSTANCES

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A brief analytical review of the modifiers of gypsum binders is given. It is shown that the modification of gypsum binders enhances the physical and mechanical characteristics: strength, water resistance. It is possible to use as modifiers: sludge of water treatment of Novopolotsk HES, cinder of «Belorusskaya GRES», fiberglass of JSC «Polotsk-Steklovolokno».

One of the main tasks of the construction industry enterprises is the improvement of consumer qualities and functional properties of products: strength, lightness, heat, sound- and water resistance. Today materials and products from gypsum are one of the most popular on the construction market, and the improvement of the properties of these building materials by modifying gypsum binders is an urgent task.

For the preparation of composite gypsum binders, such modifications of gypsum binders as sludge of water treatment of HES, cinder-fly, ceramic dust, brick waste, ground quartz sand, microsilica can be used. The resulting modified binders are characterized by a new level of technological properties compared to the previously known waterproof gypsum binders and have improved operational properties [1].

The performed studies [2] showed that the effective modifier of a gypsum binder is a sludge of water treatment which contains compounds of calcium carbonate. It was shown [3] that modification of the construction gypsum with complex additives based on fine carbonate affects the process of organization of the structure of the material and promotes the formation on the surface of the elements of the crystallization structure of the hardened stone shielding protective films from hardly soluble calcium phosphates. It is noted [3] that the modified building gypsum has increased strength and water resistance, and in the manufacture of products, the consumption of the binder is reduced.

The solution of the problem of increasing the physical and technical properties of gypsum materials and products can be achieved by the creation of crystalline hydrate neoplasms of increased density and strength due to the use of various nanomodifiers. Voitovich E.V [4] it was proposed to use a nanostructured silica component in the composite gypsum binder. As a result, the strength is increased to 40%, the water absorption decreases and the density is slightly increased. Based on this composite binder, which makes it possible to obtain products with improved performance properties, it is proposed to produce pierre-grate plates.

The studies carried out in [5] on determining the effect of ultradispersed additives on the structure and properties of anhydrite compositions showed that with an increase in the content of additives, a monotonous increase in the mechanical characteristics of the composite material occurs. When ultrafine powders are used, the strength of the anhydrite composition increases, the water resistance increases by 20–60%, depending on the type of the ultradisperse additive, the water absorption decreases from 12,7 to 10,4%.

A qualitatively new level of material properties is provided by composite gypsum binders of low water demand (CGB) [6]. CGB is a homogeneous mixture of any gypsum binder with a hydraulic component, previously obtained by joint activation of portland cement, siliceous additive and superplasticizer. This hydraulic component is an organomineralic modifier (OMM) of gypsum binders. OMM includes: a siliceous mineral additive, which can be used as cinder-fly, ceramic dust, waste from the production of bricks and other ceramic products, broken glass, fine quartz sand, microsilica, silica gel, spent silica gel, and the like materials; portland cement of any variety of grades 400–500; lime, dry plasticizing additive (superplasticizers based on naphthalenesulfonic acids or carboxylates, technical lignosulfonates, etc.). It is noted [6] that by varying the composition, components and dispersity, it is possible to obtain OMM intended for the production of composite binders for various application conditions.

To produce gypsum materials and products with improved properties, mineral additives and fillers are widely used. Among them, the use of micro- and nanofibres for reinforcing gypsum stone is of interest, their positive influence on the physical-mechanical as well as the operational properties of the products is noted. It is established [7] that the strength of gypsum material is increased due to the introduction of fibrous materials such as glass fibers, basalt and polymer fibers in combination with various additives into the composition of the raw mixes.

Of practical interest are studies aimed at studying the feasibility of effective use sludge of water treatment of Novopolotsk HES as a modifier of gypsum binder. 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

$CaCO_3$	$3MgCO{\cdot}MgOH{\cdot}2H_2O$	$CaSO_4{\cdot}2H_2O$	$Fe(OH_3)$	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%

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 [8] and it was 2170 kg/m^3. The bulk density corresponds to STB EN 1097-3 [9] and was 780 kg/m^3. The sludge of water treatment was introduced in an amount of 5% of the mass of the binder.

As a modifier, the cinder of «Belorusskaya GRES» as well as 5% of the mass of the binder was also considered. The chemical composition of the cinder is shown in table 2.

Table 2. – Chemical composition of the cinder-slag mixture of the «Belorusskaya GRES» (mass. %)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	etc.
87,62	4,39	1,08	3,08	0,55	0,61	1,79	0,24	0,19	<0,10	0,07

According to the chemical composition, the ash and slag mixture consists mainly of silicon and aluminum oxides (more than 90%). By modulus of basicity, the cinder-slag mixture refers to the low-calcium mixture, the calcium oxide content is about 3%. The cinder-slag mixture was dried at a temperature of 110 ° C. to constant weight. In the experiments, a fraction passed through a № 008 sieve was used.

As a reinforcement additive, a waste of production of the fiberglass of JSC «Polotsk-Steklovolokno» was used - cutting of alkali-resistant fiberglass SSSH-160 (100) – 1800/1800. The main characteristics of the grid: the size of the cross-section is 20 x 25 mm; nominal weight – 160 g/m^2.; breaking load – 1800 N; chemical resistance is very high. The content of the reinforcing additive in the composition of the raw mix was 5% of the mass of the gypsum binder.

To conduct experimental studies, gypsum was used for construction of «Taifun Master» № 35 of G-5 III A grade manufactured by LLC «Taifun». Determination of the physico-mechanical characteristics of the modified gypsum binder was carried out on samples of beams by size 40 x 40 x 160 mm. Testing of the samples was carried out 2 hours after molding in accordance with GOST 23789 [10] on a hydraulic press of PGM - 500 MG 4A. The results of the studies are presented in table 3.

Table 3. – Physical and mechanical properties of modified gypsum binder

Composition number	Composition	Density, kg/m^3	Strength, MPa (%)	
			to bend	for compression
1	Control	1765,6	2,9 (100)	5,2 (100)
2	With the addition of sludge	1695,3	3,3 (113,8)	7,7 (148,1)
3	With the addition of fiber	1691,4	4,7 (162,1)	6,4 (123,1)
4	With the addition of cinder	1664,1	3,6 (124,1)	5,2 (100)
5	With the addition of sludge and fiber	1639,3	3,1 (106,9)	5,3 (101,9)
6	With the addition of cinder and fiber	1614,6	3,1 (106,9)	5,9 (113,5)

Analysis of the obtained results allows us to establish that the introduction of a water treatment slurry of 5% leads to an increase in flexural and compressive strength. The flexural strength increased by 13,8% compared to the strength of the control composition, the compressive strength by 48,1%.

Reinforcement of gypsum stone with cuttings of a glass mesh in an amount of 5% of the mass of the binder increases the bending and compression strength by 62,1% and 23,1%, respectively, compared to the control samples.

Analysis of the results of the studies showed that the introduction of ash additive leads to an increase in bending strength by 24,1%, the compressive strength remained at the level of the control sample.

The joint introduction of sludge of water treatment and cutting of the fiberglass (composition 5) in an amount of 5% of the binder weight leads to an increase in bending strength by 6,9% and a compressive strength by 1,9% in comparison with the control composition in the gypsum binder sludge. The strength of the gypsum binder, which contained cinder in its composition as a modifier and was reinforced with cuttings of the fiberglass (composition 6) increased in comparison with the control composition: bending strength by 6,9%, compressive strength by 13,5%.

Thus, the modification of gypsum binders with additives of sludge of water treatment, cinder and reinforcing by cutting of the fiberglass allows to increase the strength parameters and reduce the density of gypsum stone.

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