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RESEARCH METHODS OF FOAM PHOSPHOGYPSUM BLOCKS BASED ON PHOSPHORUS FERTILIZER WASTE

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Abstract

The materials needed for the production of foam phosphogypsum consist of gypsum, phosphogypsum waste, water, foaming agent. These materials must meet standards for use. Today, several methods of foam phosphogypsum production are common.

Let's kill. In this method, first gypsum paste or phosphogypsum waste is prepared, then special foam prepared in a foam generator is added to it. The mixture in the concrete mixer is mixed with foam and a mixture of foam concrete is obtained, which later hardens to form foam phosphogypsum. This method can be called the most used and reliable. For this method, organic foaming agents, a mixture with improved components and special foam generators are usually used.

Dry mineralization. In this method, a foam phosphogypsum mixture is obtained from a generator by combining low-performance foam with dry components. At the same time, a stable foam phosphogypsum mixture with a small amount of free water is formed. Small particles of the solid phase settle on the surface of foam bubbles. This method is used in continuous foam concrete production technology. For this method, SDO foam generator, foam foam generator and special mixers are used.

Barotechnology. With this method, foam phosphogypsum is obtained under excess pressure of all raw material components. First, water with a foaming agent is poured into the stabilizer, then all additives are added. After that, the air is sent to the air mixer with a compressor and the internal pressure is created. Foam phosphogypsum mixture is produced in a foam mixer, sent under pressure from the mixer to the mold or monolithic construction. For this method, synthetic foaming agents and stabilizers are used.

Keywords: concrete, plaster, walling of a product, manufacture, ashes, phosphogypsum foam, building materials, additive, mineral knitting, resource, phosphogypsum, phosphorite, raw material, properties, cement, energy saving, factor a mitigation.

1. Introduction

In this article, it should be noted that today "Ammofos-maxam" JSC (Almaliq Sh.) specializes in the production of ammofos, ammonium sulfate phosphate, suprefos, ammonium sulfate, electrolyte, ammonium phosphate, trisodium phosphate, etc. is operating. A large amount of waste is generated during the production of phosphorus fertilizers. It is urgent to produce new types of heat-insulating wall materials by using these wastes.

2. Materials and Methods

Used materials: As the main materials for the research, used phosphogypsum-waste produced as a result of the production of mineral fertilizers.

Chemical composition of phosphogypsum, mineral production waste Fertilizers of Almaliq "Ammofos-Maksam" JSC chemical plant, %

Table 1

The chemical composition of the obtained phosphogypsum is presented in table 1.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	P_2O_3	Na_2O	K_2O	P_2O_5
10,10	0,70	0,84	34,77	7,88	41,25	1,32	0,4	0,3	0,48
13,7	0,60	0,73	31,3	6,50	44,36	2,00	0,25	0,14	0,95

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Mineral additives to activate the surface of phosphogypsum particles - chemical analysis to identify harmful compounds in phosphogypsum waste. The reason is that harmful compounds in the waste, radiation effects and similar factors are subjected to special laboratory tests and appropriate conclusions are given.

Analysis of the chemical composition of phosphogypsum waste shows that in the absence of harmful compounds (sulfurous and sulfated), organic compounds such as SiO2, Al2O3 and oxides can take an active part in hardening.

During the study of the properties of phosphogypsum waste, dust and clay particles were identified in the phosphogypsum waste, and acceptable limits were determined.

Foaming surfactants.

Many types of foaming surfactants are produced by the manufacturing industry. In our research, foaming agents such as Zimpor PB 2000 and PB Lux were used.

Zimpor foaming agent is a surface-active substance developed for foam phosphogypsum produced by the barotechnological method, and is an environmentally friendly and biodegradable product [6].

Characteristics of Zimpor foaming agent:

- light-gray liquid without precipitation and not separating into layers;

-density 1000-1200 kg/m3 (at room temperature);

-coefficient of holding balance in gypsum paste - 0.99;

- resistance to the liquid flowing out of the foam (first drop) - 50 minutes;

-freezing temperature -3oC, does not lose its properties when re-melted.- black liquid

PB Lux foaming agent is mainly used as a foaming agent for foam phosphogypsum. It has a reddish-yellow color.

PB 2000 foaming agent for the preparation of foam phosphogypsum.

-density 1200-1650 kg/m3

- light reddish color.

Types of supplements. All additives (natural or artificial chemical products) are divided into 4 classes according to the mechanism of their action:

1-additives that change the solubility of mineral binders and do not react chemically with them;

2 - those reacting with additives, binders and forming difficult soluble or poorly soluble complex compounds;

3 - additives, forming the ready center of crystallization;

4- organic surfactants (SFM), have the ability to adsorb on the surface of the solid phase.

According to GOST 24211-2008, chemical additives for concrete are divided into the following types (according to their main effect):

Various additives are added to binders and concrete mixes to improve their properties. They affect chemical, physico-chemical processes and are divided into six classes:

Class 1: controllers of the rheological properties of compounds, they are divided into three groups: I - emollient - these include CCB-sulfite - alcoholic liquid, SDB - sulfite - fermentation liquid, water-soluble polymers. 0.15 - 0.3% of the weight of their binder is added.Class 2: water-retaining additives: active mineral additives (AMQ) - trepel, diatomite, opoka, sour ash, and air-entraining substances. The binder is added in the amount of 0.01-0.05% by weight.

Class 3: liquidizer (without water separation) - these include micro-foaming agents - soap naphtha, acidol and other substances that reduce the demand for water, as well as the consumption of binders, and are included in the amount of 0.01-0.2%.

Class 2 includes additives that control the retention and solidification processes of binders and are divided into several groups:

1. Seizure retarders (gypsum, kerosene, SSB, etc.).

2. Solidification retarders (SSB, SDB).

3. Fastening accelerators (NaF, CaSl2, K2SO4, etc.).

4. Alloying accelerators (NaSl, SaSl2, FeSl3) calcium, sodium - nitrate, etc.

5. Antifreeze additives (NaSl, SaSl2, NaNO2).

6. Activators of hardening of binders without the same clinker (NaON, Na2SO3, K2SO3, NaNO2, etc.).

Class 3 additives are divided into eight groups, and their common feature is to control and change the structure of hardening binders, increasing their density.

Class 4 additives include those that prevent steel reinforcement from rusting.

Class 5 - ultra-crushed, fillers used to reduce cement consumption and increase the density of concrete, lime, rock, phosphogypsum waste, clay, some types of blast furnace and fuel slag, etc. are included.

Class 6 includes substances that give special properties to concrete and binders, for example, anti-radiation. The use of these additives greatly helps in the economy of cement, in increasing the strength, and their amount is determined by experiment.

Complex additions:

a) complex chemical additives;

b) organomineral additives.

The correct selection of the type and amount of chemical additives in the technological system, optimization of the process, in turn, leads to an increase in the efficiency of the technique and equipment.The demand for energy-efficient and environmentally friendly building materials is increasing in Uzbekistan and around the world. To meet these requirements, the materials should be light and at the same time strong.

Gypsum binders are obtained by burning rocks containing a large amount of 2 molecules of aqueous CaSO4. Depending on the burning temperature, the degree of dehydration of gypsum with 2 molecules of water changes from half a molecule of water CaSO4 0.5N2O to anhydrous CaSO4 anhydride; The properties of combustion products are also different. Fasteners made on the basis of semi-molecular aqueous gypsum bite and harden, but are not very strong; anhydrite-based binders harden slowly but are ultimately extremely strong. Gypsum binders are divided into two types depending on their chemical composition and properties: semi-molecular aqueous gypsum and anhydrite gypsum. Semi-molecular water gypsum, in turn, is divided into construction gypsum and moldable gypsum, which are produced by burning two-molecule water gypsum at normal pressure and temperature of 150-170^{0}C; molding plaster differs from construction plaster in that it feels a little smaller, is relatively stronger and cleaner. If processed at a much higher pressure, it is possible to obtain gypsum of high strength, this gypsum is chemically similar to semi-molecular aqueous gypsum, but much stronger than it. Depending on the temperature at which anhydrite is burned, 2 types of products can be obtained from it: anhydrite cement and estrix-gypsum. Anhydrite cement mainly consists of insoluble "dead gypsum" anhydrite.It becomes active against water only when there are "catalysts", i.e., substances that enhance the solidification process, such as CaO. Estrix-gypsum is also a derivative of completely burned anhydride, but Estrix-gypsum CaSO4 begins to partially decompose into CaO and CO3, and is burned at a relatively high temperature. Calcium oxide has a catalytic effect on estrix-gypsum anhydride, as a result of which it becomes hard. Gypsum binders are divided into two main groups depending on burning conditions, bite and hardening speed:

1. Gypsum binders fired at low temperature. Such binders mainly consist of semi-molecular aqueous calcium sulfate, which are quick to bite and harden quickly. These include construction gypsum, coating, medical, and super-strength gypsum, and some other gypsum binders.

2. Gypsum binders that burn at very high temperatures. Binders consist mainly of anhydrous calcium sulfate, which are slow to bite and slow to harden. These include anhydride cement, gypsum, which is burned at very high temperatures.

Bimolecular hydrous gypsum is a soft mineral: its hardness is 1.5-2 on the appropriate scale. The density of gypsum stone is around 2.3-2.4 g/cm3, while that of chemically pure gypsum is 2.32 g/cm3. The strength of gypsum stone is wet compared to other rocks and ranges from 13 to 35 MPa. 2.05 g dissolves in 1 liter of water at a temperature of 20^{0}C. Gypsum melts the most at a temperature of 32-40^{0}C. The composition of chemically pure 2-molecule aqueous gypsum is as follows: CaO–32.56% and N2O–20.93% CO3 –46.51%. Bimolecular hydrous gypsum is often accompanied by anhydrite. In many cases, anhydrite occurs as a bed-layer. Anhydrite is also often harder (3-3.5) than the various fusible colored gypsum stones. Less soluble: 1 g dissolves in 1 liter of water. Chemically pure anhydrite contains 41.19% SaO and 58.81% SO3. Anhydride deposits are less than gypsum deposits. Gypsum rocks are very common. Gypsum is sometimes mixed with clay, sand and limestone in nature. These are clay-gypsum, a mixture of gypsum with loess - ganch, etc. Dehydration of two molecules of water gypsum is the main process in the production of gypsum binders. Many researchers have been working on issues related to gypsum dehydration. Among them, the researches of Le Chatelet, Budnikov, Bant Goff, Glazenap, Volzhensky, Belyankin and Berg can be mentioned.

Purpose: Under normal conditions, between 107^{0}C and 170^{0}C, bimolecular gypsum decomposes relatively rapidly in hemihydrate water. It loses water during decomposition.The theoretical composition of semi-molecular aqueous gypsum formed in this way is as follows:

CaO – 38.63% N2O – 6.21% CO3 – 55.16%

It loses water of crystallization according to the following scheme:

$CaSO4 \cdot 2N2O \rightarrow SaSO4 \cdot N2O + 1\ N2O$

The transition of two hydrates to a hemihydrate is observed when 1 kg of two molecules of calcium sulfate absorbs heat in the amount of 23 kcal. Dehydrated hemihydrate is not stable, it quickly absorbs water vapor in the air and turns into hemihydrate, so the binder fashion heated at 170-200^{0}C will have dehydrated hemihydrate in its composition when stored in air for a long time. Depending on the conditions of thermal operation, two types of modifications of semi-molecular aqueous gypsum can be formed: a and b. b - semi-molecular aqueous

gypsum is the main mass of semi-molecular aqueous gypsum formed when heated to 107-170^{0}C under normal conditions. In this case, water is separated in the form of steam, and it is in a small crystal structure. a - modification is often processed under pressure with saturated steam with a temperature of two molecules of aqueous gypsum not lower than 123-124^{0}C. Water in its liquid form is separated from a-semihydrate and consists of crystals in the form of clear needles or prisms. Crystals are large, therefore hemimolecular aqueous gypsum with α-hemihydrate requires less water. As a result, after mixing water and solidification of the mixture, a denser and stronger product is obtained than the one formed from a-half hydrate. As the temperature increases from 170 to 200^{0}C, the dehydration process of gypsum stone accelerates, the remaining crystallized water breaks down and anhydrous anhydride is formed. The product calcined at melting temperatures from 200 to 300^{0}C mainly consists of soluble anhydrite and a small amount of semi-molecular hydrous gypsum.

Soluble anhydrite is bitten by one another slowly, but it is extremely strong compared to semi-hydrate, when the temperature exceeds 350-400^{0}C, it gradually turns into insoluble, "overripe" gypsum: at temperatures of 450-750^{0}C, a product consisting of insoluble anhydrite is formed. . Unlike a and b hemihydrates, this product does not form a mass that plasticizes and then hardens during drying.

Water: The water used for phosphogypsum concrete is mainly potable water according to the requirements of GOST 2874-82, and water with a hydrogen index of not less than 4 (that is, it is not sour, does not turn red). Water content of sulfates should not exceed 2700 mg/l and other types of salts should not exceed 5000 mg/l. If there is any doubt about the suitability of water for concrete mixing, it is necessary to prepare comparative test samples with the supplied water and ordinary tap water.

Sea and other salt water can be used to prepare the concrete mixture, as long as it meets the above requirements. Only, when concreting the internal structure of housing and social buildings, in reinforced concrete structures above water in hot and dry climates, sea and salt water cannot be used, because the salts in this water come to the top of the concrete and corrode the steel reinforcement. The water sprayed on the concrete should be from the water mixed with the concrete.

Research methods: Research methods in conducting experimental work using the standard. Dimensions of phosphogypsum waste size module by sorting method: 5; 2.5; 1.25; 0.63; 0.315; 0.14: determined through a set of sieves of mm.

The water demand of phosphogypsum was determined in the Suttard apparatus (normal density gypsum test). The fineness of grinding phosphogypsum was determined by passing it through a sieve. The specific surface of phosphogypsum was determined using the tool No. 02 Ph-4. To determine the setting time of phosphogypsum, the starting time and the ending time are taken.These data are of great practical importance, since phosphogypsum paste, phosphogypsum solution cannot be laid in a mold or applied to plaster since the beginning of preparation. This is especially unacceptable after the preparation of the phosphogypsum solution. Uses a standard Vika tool with a needle to determine the timing of the adjustment.

The beginning of the setting is characterized by a certain period of time from the beginning until the needle is lowered to form a phosphogypsum with water that did not reach the glass for the first time. The beginning and the end of the setting are considered when the needle should be mixed until it sinks more than 0.5 mm into the phosphogypsum paste. dried to constant weight in drying cabinets.

Phosphogypsum waste was crushed in a ball mill, milling of phosphogypsum with mineral additives was carried out in grinders. The strength of the hardened paste is characterized by its ultimate strength in compression and bending according to the GOST indicator, the tensile strength of phosphogypsum (gypsum) binding and gypsum-based samples should be determined in half, at intervals of 1.5 hours.

To determine the strength and properties of phosphogypsum, the normal density of samples with dimensions of 4x4x16 cm is determined by pouring phosphogypsum paste in a special form. Bending of phosphogypsum stone is carried out on the MI-100 device in accordance with the requirements of GOST 17624-2012. The tensile strength is calculated with an accuracy of 0.1 MPa, the quality of three samples is checked, and the arithmetic average value of the test results is obtained.After determining the bending strength, half of the samples were tested for compressive strength.

3. Results

Studying the properties of foaming agents: Foaming agents are the most important component in the production of foam phosphogypsum. One of the important factors is that the foams obtained on the basis of foaming agents have the same size of pores and

high aggregative stability of the pore structure after mixing with the binder. Such mixtures are called aggregatively stable if the gas phase introduced into the mixture is preserved after mixing the components with the foam until the complete solidification process. After pouring the foam concrete mixture into the molds, due to gravitational forces, the process of water separation is observed in the lower part of the molds. The faster the process of water separation, the faster the foam concrete mass poured into the forms sinks. Currently, every enterprise producing foam concrete is experimentally determining the foam with optimal performance.

Technical, technological and operational characteristics of the product are taken into account when choosing this or that foaming agent. Foam properties have different effects on the porosity, structure and solidification of the mass. In the production industry, foaming agents and foams obtained based on them are evaluated based on various criteria. To date, there is no universal method for evaluating the effectiveness of this or that foaming agent. In each case, foaming agents are considered based on certain criteria.

Mainly the following features are considered important:

- volume increase during whipping - the ratio of the primary foam volume to the initial volume of the foam-forming substance mixture;

-equilibrium - breaking of a certain volume of foam in a unit time interval;

-dispersity - a quantity representing the average size of pores in the foam and their distribution throughout the volume;

- density - mutual ratio of liquid and gas phases;

- mechanical-structural properties - the ability to maintain the original shape for a certain time;

- lifting capacity - the ability to keep a certain amount of foreign substances on its surface without breaking the foam pores.

The foaming agent has two effects on the quality of the porous material. The surface activity of the foaming substance affects the formation of the structure of the porous concrete and ensures the necessary density of the concrete. At the same time, the addition of a foaming agent slows down the setting and hardening times of the binder.This, in turn, leads to the destruction of gypsum and a decrease in the strength of the product. Therefore, choosing the right foaming agent is important.

In order to determine which of the foaming agents has a less destructive effect, the effect on the strength of the alkaline binder, which is obtained without burning the foaming agents, was studied.

At the initial stage, the pH environment, stability and volume increase of foaming agents at different temperatures were studied [5].

The pH environment of the foaming agent should be as close as possible to the pH environment of the material used as a binder. As the difference in pH media increases, foam breakdown accelerates and this, in turn, leads to product quality deterioration.

As shown in Table 2 below, among the foaming agents considered in the studies, pH medium is the largest.

Table 2

pH environment of the foaming agent

Name	The name of the foaming agent			
	Zimpor		Zimpor	
pH environment	8,0	pH environment	8,0	pH environment

The stability of the foaming agent and the increase in volume during foaming are considered to be sufficiently influencing factors in obtaining a porous material. The foam stability method is based on recording the time taken until 50% of the initial foam volume is broken or 50% of the primary total liquid is separated.

The volume increase during foaming represents the ratio of the volume of the foam to the volume of the mixture in it. According to the increase in volume when foaming agents are whipped, the foam is divided into 3 groups:

- foam with a small increase in volume when whipped (not higher than 20);

- foam with an average increase in volume when whipped (from 20 to 200);

- foam with a high volume increase when whipped (over 200).

According to the classic technology of foam phosphogypsum, foams with an increase in volume (from 4 to 9) are mainly used during foaming. According to information in the literature, foam phosphogypsum has the maximum porosity (about 83%) in the range of 6-9 when the foam is expanded.

Table 3 below shows the results of foam stability and foam expansion at different temperatures.

Table 3

Persistence of foam depending on water temperature (minutes)

Nomi	Occupied size	Water temperature, ^{0}C			
		12	20	35	50
PB 2000	600	8	6	5	3
PB luxury	720	26	20	17	4
Zimpor	320	29	23	15	8

The obtained results show that the stability of foams decreases with increasing temperature. In our opinion, this is due to the decrease in the molecular attraction forces of water at increased temperature, which in turn led to the acceleration of water separation from the foam.

Figure 1 shows the size and appearance of foaming agents used in the experiment when mixed with water to form foam.



Figure 1. Sizes of foaming agents

Methods of studying the physical-mechanical and deformational properties of foam phosphogypsum:

The main properties of foam phosphogypsum are its strength, brands, classes and deformation properties. The strength of foam phosphogypsum depends on the binder, fine filler and chemical additives. In general, foam phosphogypsum has a smaller porous structure, the stronger it is.

When designing the composition of foam phosphogypsum, it is assigned to classes (brands) according to the resistance to foam concrete, heat insulation and cold resistance.

According to the limit of compressive strength of foam phosphogypsum, the design brand is determined relative to the compressive resistance (MPa) of cube-shaped reference samples.

The draft brand of concrete for cold resistance is determined based on the results of standard cold resistance tests of samples. This mark is determined in points where concrete can be affected by freezing and thawing many times.

Foam phosphogypsum has waterproofing and other special requirements. The compressive strength limit is determined in 28 days.

For foam phosphogypsum products, it is also possible to determine the limit of compressive strength in other terms specified in the standard or technical conditions.

The strength of foam phosphogypsum is determined by testing 3 standard samples prepared in a specific way. Samples are taken from the middle of the foam phosphogypsum mixture, molded and leveled in laboratory equipment.Prepared samples are covered with a moistened cloth for at least 24 hours in molds, the air temperature is kept at 20±20C, then the samples removed from the mold are stored in a special chamber with relative humidity, then the samples removed from the mold are stored in a special chamber with a relative humidity of not less than 95% and a temperature of 20±20C It is stored for 28 days under normal conditions.

The limit of compressive strength of concrete is 20x20x20 cm, 15x15x15 cm (basic sample) and 10x10x10 cm standard samples.

In order to bring the strength indicators to the main sample of 15x15x15 cm, it is necessary to multiply the scale coefficients by 0.95 and 1.05, respectively, when testing samples with sides of 10 cm and 20 cm [6].

The strength of foam phosphogypsum directly depends on the same location of its structural components. In order to ensure that the structure of foam phosphogypsum is uniform, it is necessary to thoroughly mix the constituents. Foam phosphogypsum project brand should be equipped with high-quality gypsum, foaming agents, chemical additives, technological processes, and automated production. The guaranteed brand of foam phosphogypsum in the project can be determined by means of its strength rating tool. The foam phosphogypsum class serves as such an indicator.

Methods of research of physico-chemical properties of foam phosphogypsum blocks based on phosphorus fertilizer waste.

Phosphogypsum concrete is a construction material that belongs to the group of lightweight concretes.Its characteristics, physical and chemical properties are similar to aerated concrete. In the production of foam phosphogypsum products, the same foaming technology is used for all of them. Foam phosphogypsum is made by adding foam to a pre-

prepared concrete mixture in barometers or industrial foam generators. Chemical reactions in foam phosphogypsum are caused by the mixture of foaming agent and water. Physico-chemical properties of foam phosphogypsum mainly depend on gypsum, chemical additives and foaming agent. The strength of gypsum stone mainly depends on its water-gypsum ratio, that is, the amount of water used to prepare normal gypsum paste [9].

The amount of water required for complete hydration (hardening) of gypsum should be 40% of the gypsum mass, i.e. S/se=0.4. 60% of water (that is, 0.25 parts of gypsum mass) is used for chemical bonding. The remaining 40% is in the pores of gypsum glue, which is called hydrogel. The size of such pores in the gel is 3-10-7 mm. The porosity of gypsum stone after solidification is 30%.

Therefore, the strength of gypsum stone mainly depends on the amount of water in it, and its physical and mechanical properties deteriorate. The greater the water-gypsum ratio (S/G) affects the strength of the gypsum.

2.4. Mathematical method of calculating the optimal composition of foam phosphogypsum blocks based on the waste of phosphorus fertilizers.

The main properties of foam phosphogypsum with the addition of KDj-3. Foam concrete, which hardens under natural conditions, shrinks significantly, which leads to a deterioration of the porous structure and also to an increase in the thermal conductivity of the material. One of the solutions to this problem is the use of a complex chemical additive.

In order to test the obtained results, the effect of KDj-3 complex chemical additive on physical and mechanical properties was conducted on the basis of Laboratory of "building materials" at Tashkent University of Architecture and Construction. All the conducted studies were carried out in accordance with the requirements of the international standard GOST 30459-2008 "concrete and lime additives".

KDj-3 complex chemical additive is used to regulate the following properties of foam phosphogypsum: plasticization heat insulation and structural foam phosphogypsum mixture to reduce water consumption, acceleration of hardening heat insulation and structural foam phosphogypsum mixture during the early hardening period (up to 3 days) for the development of energy-saving technologies, thermal insulation and structural foam phosphogypsum works can be obtained.

Composition of foam phosphogypsum, thermal insulation and structural foam phosphogypsum mixtures (table 4). "Uzkimyosanoat" JSC was used as a complex chemical additive.

Table 4

The composition of foam phosphogypsum in the laboratory, the composition of thermal insulation and structural foam phosphogypsum mixtures.

№	Material name		Composition of concrete mixture, kg/gr		
			in 1m^3 kg	5l mass control gr	With the addition of KDj-3 for a mass of 5l gr
1.	Plaster		300	1500	1500
2.	The size of phosphogypsum waste is 0-5 mm		300	1500	1500
3.	Foam concentrate		2.5	12.5	12.5
4.	Water, liter		140	700	700
5.	KDj-3 from gypsum mass the composition of the supplement	0.5%	1.5		7.5
		1%	3		15
		1,5%	4.5		22.5

Table 5

Results of compressive strength analysis of thermal insulation and structural foam concrete with KDj-3 complex chemical additives.

№	Name of samples	Additive content in % of gypsum mass	Average density, kg/m3	Compressive strength of structural expanded foam concrete (MPa) age and growth (%), days				
				1	3	7	14	28
1	For control	0	760	0.5 100	1.2 100	1.4 100	1.5 100	1.6 100
2	Hardening at normal temperature conditions	0.5	755	0.8 196	1.8 194	1.0 143	1.41 155	1.8 170
3	Hardening at normal temperature conditions	1	730	0,7 200	1,5 197	1,7 175	2.0 180	2,2 185
4	Hardening at normal temperature conditions	1.5	725	0,6 186	1,0 185	1,3 163	1,5 160	1,9 181

KDj-3, 0.5, 1, and 1.5% by mass of gypsum, by studying different compositions of foam phosphogypsum, as a result of experimental study, high efficiency of components with 1.0% additive content was observed. 4 rows of 4x4x16 cm prism-shaped samples of physical-mechanical and structural properties of foam with KDj-3M were developed and checked. In addition, the first row of control samples - 1, 1.5 and 2%, the second row - KDj-3,. Test period - hardens after 3, 7, 14 and 28 days. The test results are presented in Table 5.

Studies have shown that the density of foam phosphogypsum concrete increases by 8-10% with the introduction of KDj-3 complex chemical additive. Additives of thermal insulation and structural foam phosphogypsum KDj-3 added to the compositions increased the strength of thermal insulation and structural foam concrete during all hardening. The increase in strength is observed after 1 day. 3-day sample 96%, 7-day sample 94%, 14-day sample 73%, 28-day sample 85%.

Strength of structural heat-insulating foam concrete without additives; With the addition of KDj-3, thermal conductivity was systematically improved, the load-bearing capacity of foam concrete increased, respectively, hardened at normal temperature, in the amount of 0.5, 1, 1.5 and 2% of the gypsum mass. At the same time, the effect of foam phosphogypsum on the compressive strength of KDj-3 complex chemical additives improved the structural isolation, with the addition of KDj-3, the process of gypsum hydration continues in the samples.

Mathematical selection of the optimal composition of foam phosphogypsum blocks based on the waste of phosphorus fertilizers.

Selection of the optimal composition of phosphogypsum compositions is carried out using mineral additives.Conducted scientific research and experimental work should affect phosphogypsum compositions to improve their physical and mechanical properties, but mainly technological operations for activation, drying and attachment of grinding phosphogypsum with surfactants have an incomparable place.

Optimizing the first phosphogypsum compositions should be dried at different temperatures. In our study, drying was carried out at 100, 150, 200 and 250 0C to determine the optimum temperature. The results of the study showed that at a temperature of 100-150 0C dried phosphogypsum slows down and the strength indicators in compression and bending are low. The amount of phosphogypsum dried at a temperature of 220-250 0C is low and the strength properties are low, the installation time is short, and there is accumulation of phosphogypsum particles. The percentage of residual moisture at optimal drying temperature is determined. At the same time, phosphogypsum achieves the highest physical and mechanical properties.

The second main factor in optimizing the composition of phosphogypsum is compositions

- joint grinding of phosphogypsum surfactants with selective action mills activates phosphogypsum. For this purpose, dried phosphogypsum is crushed in a continuous selective action mill. Then mineral additives are introduced, which make up 5, 10, 20, 30, 40% of the mass of phosphogypsum, and a powder with a specific surface area is obtained from the grinding tegmon.Summarizing the results of experimental studies, the determination of the optimal composition of phosphogypsum compositions was determined after the addition of phosphogypsum waste, optimization, a composition with the following indicators was selected:

- phosphogypsum dried at a constant temperature with a constant residual moisture content of up to 1%.

- grinding of phosphogypsum with the addition of 20% of phosphogypsum composite materials.

- duration of joint grinding of phosphogypsum - 12.5 min.

Mathematical models are developed to obtain extended mixtures with predetermined characteristics based on correlation-regression analysis. Various factors:

- binder - Gypsum, kg;
- foam mixture, kg;
- complex chemical additives, kg

The optimization process is characterized by a second-order polynomial, for which the orthogonal plan of the full factorial experiment was chosen (Table 6).

The equation that describes the optimization process is:

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 - a_{1,2}x_1x_2 + a_{1,3}x_1x_3 + a_{2,3}x_2x_3 + a_{1,2,3}x_1x_2x_3 + +a_{1,1}x_1^2 + a_{2,2}x_2^2 - a_{3,3}x_3^2$$

here: a 28 days - compressive strength (28 days) bookmark mixture, MPa; a 1 - 1.5% with the addition of KDj-3 complex chemical additive; a 2 - 1% with the addition of KDj-3 complex chemical additive; a 3 - 0.5% with the addition of KDj-3 complex chemical additive, application of a complex chemical additive, 28-day sample of solidification, compressive strength - MPa (samples for testing for compressive strength are

compacted by pouring phosphogypsum paste into molds of special shapes 4x4x16 cm in size)

Table 6

Orthogonal design of a full factorial experiment

Preliminary data of planned experiments	x_1	x_2	x_3
Experience center	350	400	3
Range of change	40	10	1
High rank (x_i=+1)	353	407	3,5
Lower level (x_i=-1)	275	350	2

The optimization was carried out according to the orthogonal design of the full factorial experiment, so the effect on the strength of the expanded mixture of the analyzed factors can be expressed in the form of a second-order polynomial.

The statistical model of the strength of the expanded clay concrete mixture has the following form:

$$Y = 5{,}467 + 1{,}94x_1 + 0{,}353x_2 + 0{,}297x_3 - 0{,}183x_1x_2 + 0{,}105x_1x_3 + \\ + 0{,}002x_2x_3 + 0{,}104x_1x_2x_3 + 0{,}842x_1^2 + 0{,}015x_2^2 - 0{,}116x_3^2$$

where, Y= a 28 days - compressive strength (28 days) bookmark mixture, MPa .

Mineral supplements at 28 days of age are the optimal complex in terms of maximum strength (0.8-1.0%) + (0.5-0.25)%. This provides a 36% strength gain over cement stone without additives associated with effective water separation and a relatively small amount of slag. KDj-3 reduced the cement by 3% using a complex chemical additive, and it was found that only 15% can reduce the compressive strength, indicating the active participation of mineral additives in the hydration process. With the combined introduction of the KDj-3 complex chemical additive in maximum doses, it served to produce cement composites, save cement and significantly reduce the amount of water due to the strength of the binding stone during compaction.

4. Discussion

The same trends are maintained as the compositions harden. By increasing the hydration and pozzolanic reactions, in all cases, the hardening of the poplar was noted, with the addition of 1% of the plasticizer, the greatest strength was achieved.

It was found that the use of 0.5%, 1%, 1.5% complex chemical additive with the addition of KDj-3 complex chemical additive allows the 1% sample to achieve the greatest strength characteristics in the initial period of solidification.

For compositions, the same trends as in aqueous hardening are preserved. Due to the intensification of the hydration and puzzolanic reactions, it was found that the strength increases.However, in the initial period, the greatest strength is achieved with the introduction of a complex chemical additive at 1%.

5. Conclusions

An analysis was conducted on the reduction of phosphogypsum industrial waste, and a number of experimental tests were carried out for the production of building materials products. Today, the use of industrial waste for construction makes up 20% of the annual growth of the industry. It was analyzed that industrial waste allows to reduce material consumption, production of building materials and products, to increase their quality and to reduce the cost of products.

Phosphogypsum - waste production of large tons of phosphoric acid is now used for the production of simple and complex mineral fertilizers, as well as industrial materials to regulate the production time of gypsum. There are two main purposes in using phosphogypsum waste:

- Firstly, the use of chemical additives from phosphogypsum waste, the production of construction materials and products, the enrichment and development of the construction raw material base, the preparation of materials and products at the level of demand;

- Secondly, the rational use of industrial waste, in particular, the waste of phosphorus fertilizer and the waste of phosphoric acid production, will free up the fields, the production volume of the production enterprises will increase, and the environmental problems of the region will be improved at the same time.The use of phosphogypsum for the production of construction materials leads to a decrease in the cost of materials and products. However, it requires research on the use of phosphogypsum with improved properties.

Today, it is distinguished by the place of chemical additives in the construction and building materials industry. Today, building materials cannot be imagined without chemical additives. High results are achieved due to the high possibility of applying chemical additives to concrete and mixtures, mainly by reducing the ratio of water to gypsum, reducing the consumption of gypsum, the construction has led to the achievement of considerable economic efficiency. Improvement of the physico-mechanical properties of foam phosphogypsum was considered by adding a complex additive based on these chemical additives.

First of all, the hydration of gypsum paste was observed when a complex additive was added. Production methods, production methods and its composition of foam phosphogypsum were considered.

If we focus on the properties of the materials used, the properties of gypsum, chemical additives, properties of phosphogypsum, foam production are shown. The effect of chemical additives "KDj-3" on local plasters was studied in the methodology of the work. This is mainly due to the normal thickness of gypsum pastes and the beginning of the period of thickening of gypsum pastes, as well as the birth.

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