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REVIEW OF LITERATURE ON THE USE OF EXPANDED DUST IN CONSTRUCTION MATERIALS

Annotation

One of the directions of managing the structure and properties, economic and technical efficiency of the production and use of binders is the introduction of active and inert mineral additives of natural and man-made origin into their composition. When used as mineral additives in binders of

waste and by-products of industry, both environmental problems and the tasks of reducing the consumption of natural resources are solved to a certain extent. An extensive literary review of scientific articles on the use of expanded clay dust in gypsum, composite gypsum, mineral, geopolymer binders, in compositions based on micro-cements, for geotechnical construction, as part of reinforced concrete pipes, and also considered the development of expanded clay concrete using expanded clay dust. The composite binders obtained by scientists can expand the scope of application of building gypsum, bricks, expanded clay concrete, concretes, etc., and also partially solve the problem of industrial waste disposal, in particular expanded clay dust, cullet and others.

Key words: *Expanded clay dust, binders, waste, additives, recycling*

Today, one of the pressing issues in the field of science and technology is the comprehensive processing of natural and man-made waste, as well as their use in construction materials as corrective additives.

Currently, enterprises of the expanded clay industry annually produce hundreds of tons of finely dispersed expanded clay powder (expanded clay dust) in the form of a by-product that has no further use. The rational use and disposal of this material will help improve the environmental situation in the areas where expanded clay gravel is produced.

Expanded clay dust is a waste product from the production of expanded clay, a large-tonnage type of waste from the building materials industry, which has hydraulic activity (Figure 1).

Figure 1 - Expanded clay dust

Expanded clay dust is a by-product formed when expanded clay gravel is fired in rotary kilns. At the expanded clay plant of «Stroykombinat» LLP, about 3-5 thousand tons of expanded clay dust are generated annually. Expanded clay dust is a powdery material with a specific surface area of 2500-2800 cm^2/g and a bulk density of 1.4 g/cm^3. The average content of the main components is presented in Table 1.

Table 1 – Chemical composition of expanded clay dust

Name	SiO_2, %	$A1_2O_3$, %	Fe_2O_3, %	CaO, %	MgO, %
Expanded clay dust	51,2	18,3	7,4	6,1	2,3

Expanded clay dust can be used in the production of lightweight and cellular concrete. The granulometric composition is presented in Table 2.

Table 2 – Granulometric composition

Sample	Passing through a sieve, %		
	> 0,14 мм	0,14–1,25 мм	5–10
1	25–30	60–65	1,25–5,00
2	24-28	62-66	1,2-4,8

Due to the high content of amorphous chemically active silica, expanded clay dust has lime binding activity, simultaneously playing the role of an active microfiller and filler.

The activity of mineral supplements, i.e. the ability to bind calcium hydroxide in the presence of water at ordinary temperatures is due to the content of substances in them that are in a chemically active form. One of the methods for assessing the activity of a mineral additive is to determine the amount of CaO in mg absorbed from a lime solution of 1 g of SiO_2 additive for 30 days. The reactivity of expanded clay dust in relation to lime of calcined clay materials is explained primarily by the fact that at 600–800 °C the main component of clays - inert kaolinite Al_20_3-$2Si0_2$-$2H_20$ - is dehydrated and turns into active kaolinite anhydride - metakaolinite Al_20_3-$2Si0_2$, amorphized in resulting from the removal of hydrate water. The pozzolanic activity of the original expanded clay sand is 54.5 mg/g [1].

Many foreign scientists have conducted research on expanded clay dust and its effect on the properties of various materials [2-8, 23-28].

The optimal dosage for adding expanded clay dust to the concrete composition of reinforced concrete pipes has been established, which provides increased strength and crack resistance of products [9].

Thus, in work [10], the effect of the addition of expanded clay dust, a waste product from the production of expanded clay from the Sumgait plant (Azerbaijan), on the strength of gypsum stone was studied. The granulometric composition of expanded clay dust and its hydraulic activity to absorb lime, the dependence of the compressive strength of gypsum stone, and the content of expanded clay dust in the range of 10-50% were determined. It was established that the introduction of an additive of 10-20% expanded clay dust, grinding fineness was 250 and 500 m^2 / kg, leads to a slight decrease in the compressive strength of the gypsum binder stone from 16.0 MPa to 13.9 MPa. Allows the use of gypsum-ceramsite binders for use in dry rooms. An additive in the form of lime (5%) increases the strength of gypsum stone with expanded clay dust to 18 MPa.

The authors investigated the influence of corrective additives: lime, ground expanded clay dust, superplasticizer on the composition and structure of the composite gypsum binder. It was found that the introduction of a complex additive of lime and expanded clay dust into construction gypsum ensures the production of gypsum binder with increased strength and water resistance. Its hardening is accompanied by the hydration of semi-aqueous gypsum and the formation of low-basic calcium hydrosilicates [11].

When waste and industrial by-products are used as mineral additives in binders, the following are solved: environmental problems, problems of reducing the consumption of natural raw materials. A type of such additives with pozzolanic properties are ground calcined clays, used in ancient times to increase the water resistance of calcareous materials. One of the types of mineral additives from ready-made baked clays that has pozzolanic properties is a waste product from the production of expanded clay gravel - expanded clay dust. Every year, a large amount of expanded clay dust is generated at factories for the production of expanded clay gravel [12].

Scientists from Samara State Technical University have studied the properties of expanded clay dust. To justify the directions of its use, it is necessary to know the following data: dispersity, chemical and mineralogical composition, chemical activity. The results showed: the properties of expanded clay dust depend on the initial properties of the clay raw material, the place of formation, temperature and duration of heat treatment; the use of expanded clay dust in the production of silicate and ceramic bricks is a promising direction [13].

Authors Omirbekova A., Akmalaev K.A KazNTU named after. K.I. Satpayev conducted research on the influence of the quantity and dispersion of expanded clay dust additives of various material compositions. Based on the studies conducted, it was found that when using a mineral additive to binders and concrete, the following compositions are taken into account: granulometric, chemical, mineral and phase, as well as hydraulic activity [14].

Composite gypsum binders (CGB) have been developed with the addition of additives: expanded clay dust and cullet. Research results: the compositions of KGV have been established, the composition of which is: building gypsum, a complex of Portland cement, expanded clay dust or glass cullet (siliceous additives), superplasticizer C-3. These compositions make it possible to obtain CGB, the compressive strength during long-term hardening (at the age of 28 days) can reach 16 MPa. The resulting materials can expand the scope of application of building gypsum, and also make it possible to partially solve the problem of recycling industrial waste, in particular expanded clay dust and cullet [15].

he authors considered the possibility of using expanded clay dust as an active pozzolanic mineral additive in injection mixtures for consolidating soils based on microcements. The paper presents the results of a comprehensive study of compositions using IR spectral analysis, differential scanning calorimetry and scanning electron microscopy with X-ray microanalysis. It has been established that the introduction of an additive up to 10% by weight of cement can increase the compressive strength to 78% (5.6 MPa) [16].

The work [17] presents the results of studies of mineral additives based on industrial waste for gypsum binder. Compositions using bypass dust from JSC Krichev cementnoshifer and expanded clay dust from JSC Expanded Clay Gravel Plant, Novolukoml, as mineral additives are considered. The influence of additives on the microstructure of gypsum stone is shown. The indicators of water absorption and strength characteristics of gypsum stone at the age of 7 days were determined. It was revealed that the introduction of bypass dust makes it possible to increase the bending strength by 37.9% and the compressive strength by 33.3%. It has been established that the introduction of expanded clay dust reduces water absorption by 22.4%, flexural and compressive strength increases by 20.7 and 47.9%, respectively.

Article [18] discusses the development of expanded clay concrete using expanded clay dust. Mathematical models of compressive strength, average density and structural quality coefficient depending on the content of the super plasticizer «Carboxinor NK 15» and expanded clay dust were calculated. It has been established that the use of expanded clay dust allows saving 10% of cement and increasing the compressive strength and structural quality coefficient of expanded clay concrete with the optimal dosage of the super plasticizer «Carboxinor NK 15». A composition of expanded clay concrete, density grade D1800, strength class B25-B30, which can be used for monolithic construction, has been developed.

The use of expanded clay dust has found application in the composition of asphalt concrete. The following results were obtained: the possibility of using expanded clay dust in the composition of hot lightweight asphalt concrete as highly dispersed filler was investigated. The possibility of regulating the physical, mechanical and operational properties of hot lightweight asphalt concrete with various compositions of mineral powder and expanded clay dust has been shown [19].

Expanded clay dust is a universal raw material for the synthesis of heat-resistant compositions. The work carried out a study on the influence of a finely dispersed by-product of expanded clay production - aluminosilicate dust formed during firing of clay raw materials in a two-drum kiln on the refractory properties of composites using hydraulic Portland cement, sodium liquid glass and phosphate binders. Increased performance indicators of heat-resistant composites were obtained using both hydraulic Portland cement and phosphate binders and liquid glass [20].

The production of Portland cement is associated with a large consumption of natural mineral raw materials, which requires high energy costs, as well as huge emissions of carbon dioxide into the atmosphere. A composition of geopolymer binder based on expanded clay dust has been developed, which is captured in dust cleaning systems of kilns: dust settling chambers, cyclones, filters. To determine the composition of expanded clay dust, methods of physical and chemical analysis were used: IR spectral, differential thermal, X-ray phase analyzes and scanning electron microscopy with X-ray microanalysis. It was revealed that expanded clay dust is chemically active towards liquid glass; as a result of their interaction, products based on calcium silicate and silicic acid gel are formed. The methodology for preparing the mixture is considered and studies of the microstructure, the results of X-ray microanalysis of the resulting hardened geopolymer, as well as the results of testing standard cube samples for compression with different ratios of liquid glass to expanded clay dust at different concentrations of liquid glass are presented. The use of the developed geopolymer will significantly reduce the cost of work associated with strengthening the soil base, and will also improve the environmental situation in places where ceramic materials are produced [21].

In the work, the authors [22] consider the influence of expanded clay production waste on the properties of non-hydration hardening gypsum composites obtained by semi-dry pressing. An effective method of using waste from the expanded clay industry (expanded clay dust) as a corrective mineral additive for pressed gypsum products has been substantiated. The use of expanded clay production waste allows us to solve the following pressing problems: increasing the physical and mechanical characteristics of gypsum products, environmental pollution. The methodology for molding prototypes is presented, as well as the influence of a saturated lime solution on the process of structure formation of gypsum composites. The optimal percentage of expanded clay dust additive for the average density of a non-firing composite was experimentally determined, which significantly affects the strength and water resistance of the material, thereby increasing the competitiveness of gypsum products in the building materials market.

The article [29] shows the possibility of increasing the water resistance of gypsum binders (GB), which are obtained on the basis of synthetic gypsum, by introducing additives of industrial waste. The patterns of influence and quantity of corrective additives on the water/gypsum (W/G) ratio, strength properties and water resistance of gypsum plaster were obtained. The introduction of a one-component additive to increase water resistance does not produce a significant effect. Complex additives have been developed based on Portland cement, granulated blast furnace slag, electric furnace slag, expanded clay dust and granite screenings of various fractions, which significantly increase the water resistance of high-strength GB based on a synthetic calcium sulfate dihydrate. As a result, the water resistance coefficient increased from 0.39 to 0.82.

Scientists have developed binder material compositions with the addition of expanded clay production waste. Global warming is one of the most serious problems due to significant emissions of greenhouse gases into the atmosphere. Among the main sources of these emissions is the cement industry, which is considered one of the largest sources of CO2 emissions. To solve this problem, the authors propose a partial replacement of cement with alternative materials, such as industrial waste. This work is aimed at researching the possibility of using industrial waste generated during the production of expanded clay as an additional binding material. The influence of expanded clay dust on the properties of Portland cement was assessed by X-ray diffraction, thermal, calorimetric and compressive strength analysis methods. Expanded clay dust was used as received and additionally thermally activated at a temperature of 600 °C. It was revealed that the initial dust has an average pozzolanic activity. Pozzolanic activity of additionally activated waste increased 3 times. Result of the research: the possibility of replacing Portland cement with expanded clay dust in finished form, as well as thermally activated dust at various ratios, was shown [30].

Analyzing the above data, we can conclude that the use of expanded clay dust as an additive in the production of binders improves the physical and mechanical properties of the finished product. This use of industrial waste makes it possible to solve environmental problems by recycling them, as well as to save raw materials when obtaining binders.

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АННОТАЦИЯ

Одним из направлений управления структурой и свойствами, экономической и технической эффективностью производства и применения вяжущих веществ является введение в их состав активных и инертных минеральных добавок природного и техногенного происхождения. При использовании в качестве минеральных добавок в вяжущие вещества отходов и побочных продуктов промышленности в определенной мере решаются и экологические проблемы, и задачи снижения потребления природных ресурсов. Произведен обширный литературный обзор научных статей по использованию керамзитовой пыли в гипсовяжущих, композиционных гипсовых, минеральных, геополимерных вяжущих, в композициях на основе микроцементов, для геотехнического строительства, в составе бетонов железобетонных труб, а также рассмотрены вопросы разработки керамзитобетона с применением керамзитовой пыли. Полученные учеными композиционные вяжущие могут расширить область применения строительного гипса, кирпичей, керамзитобетона, бетонов и другие, а также позволяют частично решить проблему утилизации отходов промышленности, в частности керамзитовой пыли, стеклобоя и другие.

ТҮЙІН

Байланыстырғыш заттардың құрылымы мен қасиеттерін, өндірісі мен пайдаланудың экономикалық және техникалық тиімділігін бақылау бағыттарының бірі олардың құрамына табиғи және техногендік шыққан белсенді және инертті минералды қоспаларды енгізу болып

табылады. Тұтқыр заттарға минералды қоспалар ретінде қалдықтар мен өнеркәсіптік қосалқы өнімдерді пайдаланған кезде экологиялық мәселелер де, табиғи ресурстарды тұтынуды азайту мәселесі де белгілі дәрежеде шешіледі. Керамзит шаңын гипстік байланыстырғыштарда, композиттік гипсте, минералды, геополимерлі байланыстырғыштарда, микроцементтердің негізіндегі композицияларда, геотехникалық құрылыста, темірбетон құбырлар құрамында пайдалану туралы ғылыми мақалаларға кең әдебиеттік шолу жүргізілді, сонымен қатар керамзит шаңын қолданатын керамзитті бетоны да қарастырылды. Ғалымдар алған композиттік байланыстырғыштар құрылыс гипсін, кірпішті, керамзитті бетонды, бетонды және т.б. қолдану аясын кеңейте алады, сондай-ақ өнеркәсіптік қалдықтарды, атап айтқанда керамзит шаңын, шыны қалдықтар және т.б. қайта өңдеу мәселесін шешуге мүмкіндік береді.

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ҒИМАРАТ САЛУҒА ҚОЛАЙЛЫ ӘРТҮРЛІ ЗАМАНАУИ БЛОКТАРДЫ САЛЫСТЫРУ
COMPARISON OF VARIOUS MODERN BLOCKS FOR BUILDING CONSTRUCTION

Аннотация

Заманауи құрылыс технологиялары қабырға материалдары ретінде кірпіштің орнына әртүрлі материалдардан жасалған блоктарды көбірек ұсынады. Олар көлемі, қасиеттері және бағасы бойынша ерекшеленеді. Блоктың әрбір түрі өзінің артықшылықты қолдану аймағына ие, бірақ олардың барлығы тұрғын үй құрылысында да, өнеркәсіптік құрылыста да кірпішті алмастыра алады. Әрбір накты жағдайда тек оң сипаттамаларын көрсететін блоктарды дұрыс таңдау үшін оларды негізгі параметрлері бойынша салыстыру қажет. Материалдардың физика-химиялық қасиеттері олардың жүктеме кезінде қабырғадағы жұмысын анықтайды және үйдегі микроклиматқа айтарлықтай әсер етеді. Мақалада жеке және өнеркәсіптік құрылыста қолданылатын блоктардың негізгі түрлері талқыланады: газдалған бетон; көбік бетон; керамика; арболит; керамзит бетон т.б.

Талдау белгілі бір блоктың қасиеттеріне ғана емес, сонымен қатар олардың құрылыс материалдарының басқа түрлерімен өзара әрекеттесуіне, дайындық және әрлеу жұмыстарының күрделілігіне, құрылымды нығайту қажеттілігіне және қызмет мерзіміне қатысты болады. Үй салу үшін қандай блоктар тиімді екенін анықтау әрекеті бір немесе басқа түрдегі жарнамаға бей-жай қарамай, тек шынайы деректерге негізделеді.

Құрылыс қабырға материалдарды таңдаудағы маңызды үш критерияға мыналар жатады:

Жылу өткізгіштік. Негізінде, қабырғалардың жылу ұстағыштығы үйіңіздің жылы немесе суық болатынын көрсетеді.

Баға. Құрылысқа арналған материалдарды таңдауда, одан әрі сатып алуда баға маңызды көрсеткіш болып табылады.

Пайдалану. Үй салуды жоспарлағанда, біз пәтерден үлкен ауданға ие болып, бірнеше қабатты, кең бөлмелерде тұрғымыз келеді. Ал үйдің жылуының шамамен 35% қабырғалары арқылы жоғалатынын бәрі білмейді. Сондықтан өмір бойы ақшаңызды үнемдейтін заманауи қабырға материалдарын таңдау маңызды.