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Yerzhanova Nurgul, Kuzmina Raisa

Saratov National Research State University named after N.G. Chernyshevsky, Saratov, Russia

E-mail: nurgul.yerzhanova@mail.ru, kuzminaraisa@mail.ru

REDUCING THE ENVIRONMENTAL FOOTPRINT: INNOVATIONS IN THE DISPOSAL OF DRILLING WASTE

Annotation. The article is devoted to the urgent problem of environmental safety in the oil and gas industry. The authors propose an innovative approach to the disposal of drilling waste, which consists in their use as a mineral filler for the production of environmentally friendly gypsum-based building materials. The paper presents the results of experimental studies confirming not only the possibility of using drilling waste as a building material, but also a positive effect on the properties of the final product. The conducted environmental assessment showed that the proposed method can significantly reduce the negative impact of waste on the environment.

Experiments were carried out to vary the composition of mixtures and curing conditions. As a result, data were obtained on the influence of various factors on the strength, water resistance and other characteristics of the obtained materials. An assessment of the environmental safety of the developed materials was carried out. The results obtained indicate the prospects of using drilling waste in construction and open up new opportunities for creating environmentally friendly and cost-effective materials.

Keywords: drilling waste; gypsum binders; drilling mud; softening coefficient; water demand; thermal conductivity.

Introduction

The problem of disposal of drilling waste, especially drilling sludge, is acute for many industries. These wastes, containing various mineral components, heavy metals and organic substances, pose a significant environmental threat if improperly disposed of. In this regard, the search for effective and safe ways to dispose of them is an urgent task [1].

One of the promising ways to solve this problem is the use of drilling waste as a mineral filler in the composition of building composite materials. This approach has a number of advantages. Disposal of drilling waste reduces the burden on the environment, preventing pollution of soils and reservoirs. The use of drilling waste as a filler reduces the cost of production of building materials. Depending on the mineralogical composition of the drilling mud, its addition to building mixes can improve the strength, water resistance, thermal insulation properties and other characteristics of materials [2]. The properties of drilling mud that determine its use in construction are the mineralogical composition. The mineralogical composition of drilling mud depends on its properties and the possibility of use in construction. The presence of quartz, feldspar, clay minerals and other components can give the material specific characteristics.

The use of drilling mud as a filler in gypsum materials is a promising direction for the development of the construction industry, which allows solving several tasks at once. Firstly, it significantly reduces the environmental burden, as it reduces the amount of waste sent to landfill and reduces the need for extraction of natural resources. Secondly, the use of drilling mud as a filler reduces the cost of production of building materials, which makes them more accessible to a wide range of consumers [3]. In addition, the introduction of drilling mud into gypsum mixtures can improve material characteristics such as strength, water resistance and frost resistance.

However, for the successful use of drilling mud as a filler, it is necessary to conduct comprehensive studies aimed at optimizing the composition of mixtures and determining optimal production conditions. It is important to take into account such factors as the mineralogical composition of the drilling mud, its dispersion, as well as the type of gypsum binder [4].

A promising area of further research is the development of composite materials based on gypsum and drilling mud with special properties, for example, with increased fire resistance or sound insulation. Such materials can be widely used in the construction of residential and public buildings [5].

Thus, the use of drilling mud as a filler in gypsum materials is not only an environmentally sound, but also an economically profitable solution. This allows not only to reduce the negative impact on the environment, but also to create new, promising building materials. The use of drilling mud as a filler in gypsum materials is a promising direction for the development of the construction industry [6]. This approach makes it possible to solve environmental problems, reduce the cost of building materials and create new materials with improved properties. Further research in this area will expand the possibilities of using drilling mud in construction and create more environmentally friendly and cost-effective materials.

Materials and methods of research

One of the most common brands of construction gypsum binders, G–4 - G–6, was used as a feedstock in this scientific study. The production technology of composite construction gypsum binders involves the introduction of an active mineral component (AMP) into the system, in our case, AMP is activated carbonate sludge from the Karashyganak gas condensate field, which is a waste product.

Methods for determining the softening coefficient

The softening coefficient is an important indicator characterizing the water resistance of the material. It is defined as the ratio of the strength of a material in a water-saturated state to its strength in a dry state.

There are several methods for determining the softening coefficient, the choice of which depends on the type of material and the required accuracy of the results. Samples of the material of standard sizes are produced. Some of the samples are dried to a constant mass, and the other part is saturated with water to a constant mass. Then both groups of samples are tested for strength under the same conditions.

The softening coefficient is calculated according to the formula [6]:

$$К_p = R_n / R_c \quad (1)$$

Where, $К_p$ is the softening coefficient; R_n is the strength of the sample saturated with water; R_c is the strength of the dry sample.

The water resistance of gypsum binders is an important indicator characterizing their ability to maintain strength under prolonged exposure to moisture. To determine it, there are several methods, each of which has its own characteristics and is used depending on the specific goals of the study.

The coefficient of thermal conductivity is an important characteristic of building materials, which determines their ability to conduct heat. For gypsum binders widely used in construction, the precise definition of this parameter is especially important for calculating the thermal insulation properties of structures.

The thermal conductivity coefficient of a material is determined by comparing it with a reference material with known thermal conductivity. It is used in the absence of special equipment. The accuracy of the method depends on the accuracy of determining the properties of the reference material [4].

Research results

To create a new composite material based on gypsum and drilling mud, its chemical composition was determined. The composition of this filler is shown in Table 1. The pH value is 7.97.

Table 1 – Composition of carbonate drilling mud

Anions	
Cl^-, %	10,196
SO_4^{2-}, %	0,6336
Kations	
K^+, mg/kg	6165,9
Na^+, mg/kg	21661,4
Cu, mg/kg	17,2744
Co, mg/kg	0,83
Zn, mg/kg	57,3336
Ni, mg/kg	0,7056
Pb, mg/kg	16,162
Other substances	
Organic matter, %	7,84
Petroleum products, mg/dm^3	0,083

The high content of K+ and Na+ ions indicates good metabolic characteristics of the sludge. The content of hydrocarbons (petroleum products) does not exceed 1% by weight, which is a regulatory indicator of the quality of processing.

Due to the positive data of the drilling mud and the tasks set, composite binders were obtained (table 2).

Table 2 – Chemical composition of the developed composite materials

№	Composite materials	$m_{general}$, g	m_{gipsum}, g	m_{sludge}, g
1	Gypsum 100%	100	100	0
2	Gypsum 95% Sludge 5%	100	94	5
3	Gypsum 90% Sludge 10%	100	89	10
4	Gypsum 85% Sludge 15%	100	84	15
5	Gypsum 80% Sludge 20%	100	79	20
Note: the content of the setting retarder (H_3BO_3) is 1% of the total mass of CM				

Previously, it was experimentally established that when a nanostructured binder was introduced into a gypsum system as an AMC, a significant improvement in the structural, physical, mechanical, and technical and operational characteristics of the initial binder system was observed. An explanation of this effect is possible provided that the complex effect of AMC on the gypsum binder system is considered.

Features due to the polyfractive composition of AMC, when it is introduced into the gypsum system, the effects of AMC can be considered at both the micro and nanoscale. Particles of the maximum size in AMC (1-100 microns) work in a composite gypsum binder as a micron filler, which contributes to the creation of the most dense defect-free structure of the matrix phase of the binder. The effect of AMC in the system occurs both at the level of the binder matrix and at the contact zone, which in turn leads to an increase in the quality and efficiency of gypsum materials.

The number of these components was calculated based on the total mass of the material. Boric acid plays the role of a setting retarder. An analysis of the research results showed that an increase in the degree of filling of construction gypsum leads to a decrease in its water absorption, but the water retention capacity and humidity increase, which makes it possible to obtain binders with good water resistance.

Along with the positive properties of gypsum products, low water resistance is inherent. These negative properties of gypsum products reduce the scope and scope of their use in construction. Analyzing the literature sources, it can be concluded that an increase in the water resistance of gypsum is achieved by reducing the solubility of calcium sulfate in water, compacting the gypsum mass, impregnating the product with substances that prevent moisture from penetrating into it and external protective coating of products.

When determining the softening coefficient of the obtained samples, the duration of the beginning of setting of the gypsum dough increases from 4 to 8 minutes and the end of setting from 9 to 20-22 minutes.

The principle of action of a mineral additive, that is, a carbonate sludge, is based on the scattering of static charges and spatial stabilization of binder particles, which leads to highly efficient dispersion and deflocculation. Thus, being adsorbed on hydrating binder grains, the additive extends the setting time and reduces water demand, which causes an increase in strength indicators (fig.1).

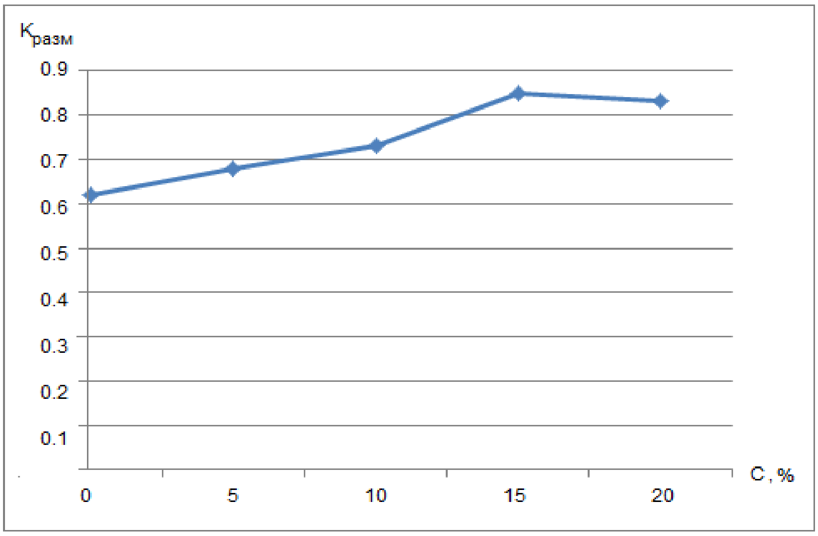

Figure 1 – Curve of the softening coefficient dependence on the concentration of the mineral additive

The reason for the increase in water resistance is the positive effect of the mineral additive, which consists in the fact that the particles of the redispersed powders are distributed in the structure of the material, forming a continuous polymer framework.

The formation of such polymer films in the interstitial space leads to internal gibrophobization of the material. After 7 days of hardening, gypsum binders modified with the additive have a softening coefficient greater than 0.85, which allows these binders to be considered water-resistant.

As well as reducing the porosity of composites by increasing the amount of sludge, it contributes to an intensive improvement of its properties. Due to the fact that the number of open pores of composites is less than micropores, these materials are waterproof. By changing the type, dispersion and amount of filler, it is possible to control the properties of the binder and influence the structure of the hardened material.

And with an increase in the amount of water-retaining additive, there is no decrease in the strength of the solution and its adhesion increases. This is due to the fact that the additive, penetrating into the pores of the solution, practically reinforces the gypsum stone. The rigid frame of the solidified solution becomes more plastic, the modulus of elasticity decreases.

One of the most important indicators of gypsum binders is thermal conductivity. This is the ability of a material to transfer heat through its thickness due to the temperature difference on the bounding surfaces. This property is characterized by the coefficient of thermal conductivity λ (W/(m·°C)) [9]. In order to determine the thermal protection properties of the obtained binders, tests and calculations were carried out (fig.2).

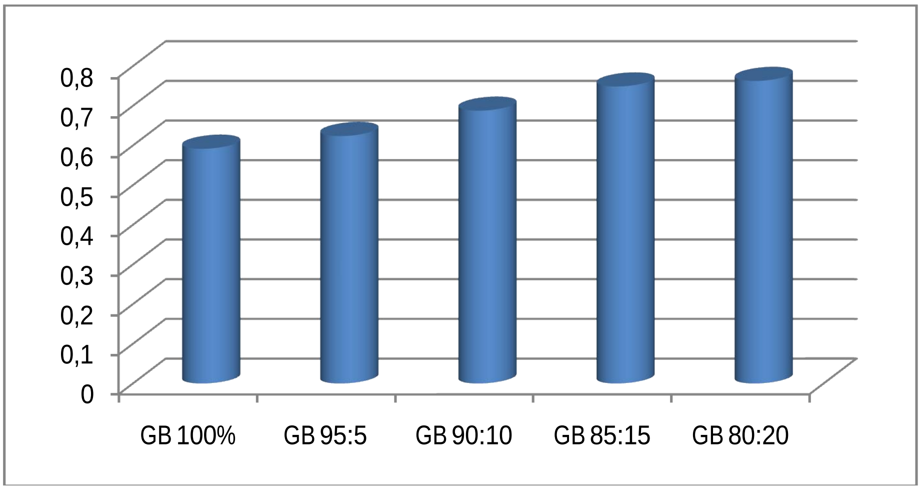

Figure 2 – Comparative diagram of the value of thermal conductivity coefficients (λ) of composite materials

The thermal conductivity of gypsum composite materials is related to the composition, structure, texture, density, humidity, and ambient temperature [10]. With an increase in the density of the material, the thermal conductivity decreases, since the thermal conductivity of the air λ = 0.023 W/(m·°C) (at T = 20 °C) is always less than the thermal conductivity of the solid of which the building material consists.

Conclusion

As a result of the conducted research, it was found that the introduction of activated mineral powder from carbonate drilling mud into the composition of gypsum binders makes it possible to obtain composite materials with improved properties. The optimal sludge content was 15%, at which the compressive strength of the obtained samples increased by 20%, and water absorption decreased by 15% compared to the control samples. Mechanical activation of the sludge allowed to increase its dispersion and reactivity, which contributed to a more effective interaction with gypsum and the formation of strong structures. Composite materials obtained on the basis of modified gypsum binders are characterized not only by high strength and water resistance, but also by environmental safety, as they reduce the amount of waste sent to landfill.

Further research will be aimed at expanding the scope of application of the obtained materials, as well as exploring the possibility of using other types of industrial waste as additives to gypsum binders.

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Ержанова Н.С., Кузьмина Р.И.

ЭКОЛОГИЯЛЫҚ ІЗДІ АЗАЙТУ: БҰРҒЫЛАУ ҚАЛДЫҚТАРЫН ҚАЙТА ӨҢДЕУДЕГІ ИННОВАЦИЯЛАР

Аңдатпа. Мақала мұнай-газ саласындағы экологиялық қауіпсіздіктің өзекті мәселесіне арналған. Авторлар бұрғылау қалдықтарын қайта өңдеудің экологиялық таза гипс негізіндегі құрылыс материалдарын өндіру үшін минералды толтырғыш ретінде пайдалану инновациялық әдісін ұсынады. Жұмыста бұрғылау қалдықтарын құрылыс материалы ретінде пайдалану мүмкіндігін ғана емес, сонымен қатар соңғы өнімнің қасиеттеріне оң әсерін растайтын эксперименттік зерттеулердің нәтижелері келтірілген. Жүргізілген экологиялық бағалау нәтижесінде ұсынылған әдіс қалдықтардың қоршаған ортаға теріс әсерін едәуір төмендетуге мүмкіндік беретіндігін көрсетті.

Қоспалардың құрамын және қату шарттарын өзгерту бойынша зерттеу жүргізілді. Нәтижесінде алынған материалдардың беріктігіне, суға төзімділігіне және басқа сипаттамаларына әртүрлі факторлардың әсері туралы мәліметтер алынды. Әзірленген материалдардың экологиялық қауіпсіздігіне бағалау жүргізілді. Алынған нәтижелер құрылыста бұрғылау қалдықтарын пайдаланудың перспективалылығын көрсетеді және экологиялық таза және үнемді материалдар жасау үшін жаңа мүмкіндіктер ашады.

Кілт сөздер: бұрғылау қалдықтары; гипсті байланыстырғыштар; бұрғылау шламы; жұмсару коэффициенті; су тұтыну; жылу өткізгіштік.

Ержанова Н.С., Кузьмина Р.И.

СОКРАЩЕНИЕ ЭКОЛОГИЧЕСКОГО СЛЕДА: ИННОВАЦИИ В УТИЛИЗАЦИИ ОТХОДОВ БУРЕНИЯ

Аннотоция. Статья посвящена актуальной проблеме экологической безопасности в нефтегазовой отрасли. Авторы предлагают инновационный подход к утилизации отходов бурения, заключающийся в их использовании в качестве минерального наполнителя для производства экологически чистых строительных материалов на основе гипса. В работе представлены результаты экспериментальных исследований, подтверждающих не только возможность использования отходов бурения в качестве строительного материала, но и положительное влияние на свойства конечного продукта. Проведенная экологическая оценка показала, что предложенный метод позволяет значительно снизить негативное воздействие отходов на окружающую среду.

Были проведены эксперименты по варьированию состава смесей и условий отверждения. В результате получены данные о влиянии различных факторов на прочность, водостойкость и другие характеристики полученных материалов. Проведена оценка экологической безопасности разработанных материалов. Полученные результаты свидетельствуют о перспективности использования отходов бурения в строительстве и открывают новые возможности для создания экологически чистых и экономически эффективных материалов.

Ключевые слова: отходы бурения; гипсовые вяжущие; буровой шлам; коэффициент размягчения; водопотребность; теплопроводность.