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Prospects of Industrial Use of Concretes Based on Modified Sulfur Binders

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Annotation

This article discusses the improvement of physical, mechanical and operational properties of composite materials modified with sulfur binder plasticizers used in the modern construction industry. Also, the effect of plasticizers on the fire resistance properties of composite materials was studied. In addition, on the basis of an in-depth analysis of the literature, the importance of the type and size of fillers and their mixing technology in the formation of a low-porosity structure of a sulfur-binding composition material was studied. In the article, the method of obtaining a stable sulfur-binding composite material, the preparation of a solid filler, soaking the filler in an organic modifier, wetting and heating the filler with the modifier, mixing it with elemental sulfur, and cooling to form a solid product are thoroughly covered.

Keywords: Sulfur concrete, modification, glass fiber, flint, dispersed filler, mechanical properties, flammability, thermal conductivity.

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1. Introduction.

With the development of technology, most of the disadvantages have been eliminated. Thus, the addition of sulfur binding plasticizers (in particular, polysulfides) helps not only to increase the plastic properties of the alloy, but also to reduce cracks, and additives in the form of dicyclopentadiene increase the fire resistance of these building materials [1-3].

The properties of sulfur-containing concrete are the result of its internal structure, which is currently being studied in great detail [4] . Without the addition of fillers, sulfur is a substance with a homogeneous structure (homogeneous), which means that the molecules in it are densely arranged relative to each other. In the presence of the filler, the sulfur molecules fill the internal spaces of the studied binder by "attaching" the filler molecules in such a way that the porosity in it is almost imperceptible (even under a microscope). Small porosity in sulfur-containing concrete largely depends on the areas of its application [5]. This is due to the use of sulfur-containing concrete as the main material for waste storage, waste water collectors and other structures.

The main technological parameter in the production of sulfur concrete is the viscosity of the sulfur solution, because it determines such technological properties as the ability of mineral fillers to form a homogeneous mass. It is known that in composite building materials, the filler comes into contact with the binder in a significant area due to the improved surface area [6] .

At the first stage of the interaction of the binder and the mineral filler, the surface of the mineral fillers and the surfaces of the ultrafine fillers are wetted. Therefore, in the production of sulfur concretes, the formation of the main structure occurs at the stage of mixing the filler with dissolved sulfur . In this case, during the cooling of sulfur, homogeneous crystals are formed on the surface of the mineral filler, their sizes are much smaller than those of sulfur without filler [7] . At the optimal filling level, almost all sulfur is converted to a homogeneous fine crystalline state. The reduction of sulfur crystals not only determines the strength of the sulfur binder. A film of optimal thickness is formed around the filler grains.

In Saudi Arabia, the use of sulfur-sand-bitumen mixture for road construction works has allowed savings of 60 percent of funds compared to traditional asphalt concrete in terms of estimated costs of materials, labor and equipment. Although the cost of sulfur is a bit high in some European countries, the use of sulfur-sand-bitumen mixtures gives very good results in places where good quality fillers are not available [8-9] .

2. Research methodology

In the method of preparing sulfur concrete mixture, a mixture of aggregates consisting of 10 mm thick flint, 3 mm sand, preheated to 160°C is placed in a heated forced-moving concrete mixer, mixed, sulfur mixture heated to 160°C, iodine modifier is added and mixed, to the obtained mixture forms or the concrete is dropped into the placer. The composition of the sulfur concrete mixture by weight is as follows: basalt waste filler pebble 31.65-44.26 + sand 24.07-33.64%. Mix them for 1-2 minutes at a temperature of 160°C . The composition of the binder is sulfur 13.550-27.13, iodine 0.005-0.01, filler - IES ash 8.545-17.14. Binder and filler mixtures are mixed at 160°C for 2-3 minutes.

The method of obtaining a stable sulfur binder composite material includes the preparation of a solid filler, soaking the filler in an organic modifier, wetting and heating the filler with the modifier, mixing it with elemental sulfur, and cooling to form a solid product [10-11] . The invention makes it possible to obtain stable and highly durable sulfur composite materials.

The method of obtaining a composite material with a stable sulfur binder includes the following operations:

- preparation of solid fillers in the group consisting of a combination of mineral fillers, slag, silica sand, secondary products of industrial production;
- soaking the filler in the organic modifier with diesel oil prepared for the purpose of impregnating the filler and with dark petroleum oil containing catalytic cracking residue;
- wetting and heating the filler with a modifier in order to activate the surface of the filler with sulfur;
- powdered solid or dissolved elemental sulfur is added to the filler soaked in the modifier;
- optional solid sulfur is stirred to bind the filler soaked in the modifier with elemental sulfur at a temperature sufficient to melt;
- the liquid mixture is cooled until it takes the form of a solid product.

Technical sulfur, sulfur compound waste can be used to prepare sulfur concrete [12]. Dense rocks, artificial and natural porous materials, production waste (grinding grains of rock and sedimentary rocks) are used as inert fillers and fillers [13-14] .

Sulfur binder production technology is simpler and cheaper than cement production technology. According to the results of production development, the production technology of sulfur binders has the following indicators compared to traditional methods with cement: energy consumption is reduced by 1.5-2 times; environmental safety of production is increased; capital costs for production organization are reduced by 40-50%; waste-free production is achieved; the cost is reduced by 1.5-2 times;

- storage period is significantly increased (almost without limitations).

3. Analysis and results

To increase fire resistance and properties of concrete materials based on sulfur-containing binders, polymer modifiers were proposed and their optimal conditions and physical-mechanical properties were studied.

It is known that the value and economic efficiency of innovations in the construction materials production industry always increase when they can be solved simultaneously as a result of their simultaneous use [15] . Concretes based on sulfur-containing binders differ from ordinary heavy concretes by their low water permeability and water permeability, their ability to retain their shape and strength in a short period of time, and their high resistance to corrosion. At the same time, there are certain negative properties that limit the use of concretes based on sulfur-containing binders, which are attributed to their low temperature (140 ^{o} C), thermal resistance and high toxicity in production [16-19] . In order to eliminate the main shortcomings of concretes based on sulfur-containing binders, to expand their use, and to obtain constructive materials from them, the authors developed fire-resistant sulfur-containing concretes based on MB-100 modifiers (tables 1 and 2).

The technology of making concrete based on sulfur-containing binders is carried out according to the following: sand with a size of 4-5 mm, pebbles with a size of 10-50 mm, sulfur in the required amount and modifiers that improve flammability and mechanical properties of the MB-100 brand are added and heated at a temperature of 1130-170^{o} C, and the room cooled at a temperature [20-21] . The composition of prepared concretes based on sulfur-containing binders is presented in Table 1

Table 1. Optimum composition of modified sulfur-based concretes

T.r	Contents	Sample composition, %		
		Standard	MB-100 brand modifier concrete base	Concrete based on traditional modifier
1	Pebble	40	35	35
2	Sulphur	30	36	30
3	Sand	30	23	25
5	MB-100 brand modifier	-	6	-
6	Pyrilax	-	-	10

Table 2. Properties of sulfur concrete prepared on the basis of MB-100 brand modifier

T.r	Indicator name	Standard	Brand MB-100 modifier	Pyrilax-based concrete sample
1	Density, kg / m ^{3}	2200	2140	2200
2	Compression strength, MPa	62	63	58
3	Bending strength, MPa	12	12	1 0
4	Time to ensure consistency, hours	1.1	1.1	1.1
5	Heat transfer coefficient	0.08	0.08	0.08
6	Chemical resistance - to acid, alkali and salts	85	85	85
7	Flammability group	III	II	II

The physical-mechanical, chemical and thermophysical properties of the selected compositions were determined based on the requirements of the current normative documents for determining the optimal amount of MB-100 modifier (Table 2).

Physical-mechanical, chemical and thermophysical properties of concretes based on sulfur-containing binders were determined on the basis of current normative documents (Table 2). The density of concretes based on sulfur-containing binders prepared on the basis of MB-100 modifier flammability-reducing compositions was achieved due to the addition of a certain amount of additives to the composition by approximately 1.5-2%.

Conclusion.

It was observed that the compressive and bending strength indicators of sulfur-containing concrete prepared on the basis of MB-100 brand modifier additives, which reduce flammability, increased by 3-4% compared to the strength of ordinary sulfur-containing concrete.

The effect of MB-100 modifier brand additives on the setting time of sulfur-containing concretes was not noticed, achieving the same strength as conventional sulfur-containing concretes for 1.1 hours.

Sulfur-containing concretes based on MB-100 modifier brand flammability-reducing additives from the chemical resistance of traditional sulfur-containing concretes. MB-100 modifier, which was added to concretes based on sulfur -based binders to reduce their flammability, increased the thermophysical properties of concrete without changing physical-mechanical, chemical properties, and transferred the material from the combustible group to the hard-to-burn group.

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