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TECHNOLOGY FOR THE PRODUCTION OF COMPOSITE MATERIAL-SULFUR CONCRETE PRODUCTS FROM MODIFIED SULFUR

YESSENAMANOVA ZH.S. , **KAPINA M.A.***

Yessenamanova Zhanar Sanakovna — PhD Doctor, Acting Associate Professor, Atyrau University named after Khalel Dosmukhamedov, Atyrau, Kazakhstan;
E -mail: zhanyessen@mail.ru; https://orcid.org/0000-0003-3868-4092
***Kapina Madina Asetullaevna**- 2nd year Master's student, EP 7M05201 – «Applied Ecology», Atyrau University named after Khalel Dosmukhamedov, Atyrau, Kazakhstan;
E-mail: kapina.m01@mail.ru; https://orcid.org/0009-0006-7374-4723

Abstract. Due to the increase in the processing of sulfur-containing hydrocarbon raw materials (oil and gas), sulfur is released as one of the large - tonnage waste. Long-term storage of large sulfur reserves has a negative impact on the environment. Composite material of sulfur modification-characterized by environmental efficiency, economic efficiency in construction. This review examines the sources of sulfur origin, properties, technology for making sulfur concrete from it and the use of sulfur-based concrete in the construction industry today. Experimental evaluation of modified sulfur concrete, other methods of preparation of mixtures were identified, and the importance of adaptation to foreign experience in the development of sulfur concrete production was shown. One of the most promising projects is the production of concrete containing sulfur binder in order to reduce the load on the environment. After all, sulfur concrete has such advantages as resistance to acid and radiation, frost resistance and the ability to recycle. The aim of the work was to study a new composition of sulfur concrete based on a bitumen composition. To conduct the study, samples of sulfur concrete with different percentage contents of the constituent components were prepared.

Key words: sulphur concrete, admixture, sulfur modification, chemical resistance, composite material, chemical bond, fillers, sulfurassfalt concrete.

Today, the world pays special attention to the creation of new modified sulfur binders. Because, having gone through an industrial cleanup process, fossil fuel consumption has increased.

Sulfur concrete is a thermoplastic composition of mineral filler as a binder (instead of cement and water) at a temperature of over 120 ° C. To obtain sulfur concrete with high physicochemical and mechanical properties, the components must meet certain requirements: have fewer free spaces and porosities in the concrete, ensure the maximum density of the material to ensure high strength, high resistance to aggressive chemical environment and sudden changes in temperature, porosity should be as low as possible, ensuring low moisture absorption should be.

The advantages of sulfur-based concrete over Portland cement concrete are high acid and radiation resistance, low electrical conductivity, water resistance, frost resistance and recyclability. Sulfur concrete is used in the production of monolithic structures, as well as in various repair work.

Currently, two main areas of sulfur use in construction have been identified. The first is the production of polymer concretes from mineral aggregates and sulfur mixtures using asphalt technology, the second is the use of sulfur concrete in the manufacture of road surfaces.

The goal of this work is to describe a cost-effective, non-complex process technology for sulfur concrete equivalent to bitumen, the manufacture of which consumes less energy than bitumen. Ecological research of innovative technologies.

1. Structure, properties and application of sulfur

Sulfur atoms have a number of different allotropic modifications to form ring or chain molecules. It can be classified into two types: those formed as a result of chemical bonds between sulfur atoms and those formed due to the location of the sulfur molecule inside the crystals.

Sulfur atoms combine to form chains and cyclic rings (cyclo-S_n : where n represents the number of atoms), allowing for the existence of millions of sulfur allotropes (molecular). If S_n molecules have 6-12 sulfur atoms, they are in ring form (very stable), while molecules with less than six or more than twelve sulfur atoms can be in ring or chain form (very unstable). Several crystalline forms of sulfur are known, among which the most stable are rhombic α-sulfur and monoclinic β-sulfur. The density of sulfur is 2.07 g/cm^3 (α-type) and 1.96 g/cm^3 (β-type), melting point t 112.8°C, boiling point t 444.6°C, thermal conductivity 0.208 W/(m· degree). [2]

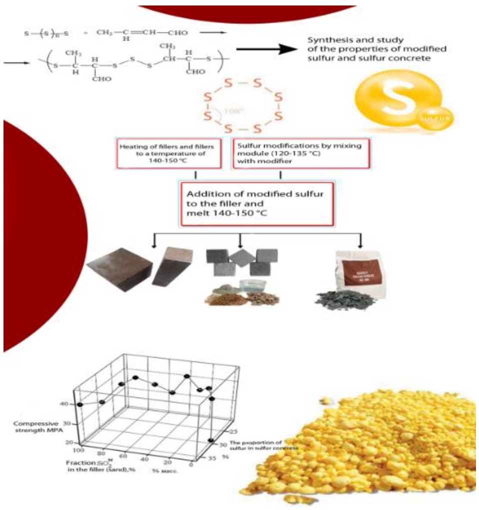
Sulfur concrete samples are made from modified secondary sulfur, sand, aggregates. Durability of sulfur concrete is tested in 10% HCl, 20% H_2SO_4 and 3% NaCl. Modified sulfur binder protects against shrinkage, collapse, increases durability of sulfur concrete.[1]

Table 1. Modifiers and fillers for sulfur concrete. [3]

Inorganic additives		
Modifier	Sulfur mass concentration %	The result
Heavy metals and Hg	6	Acid resistance
Alumina	20-26	
Fly ash	20-23	
Silicon dioxide	22-25	
Organic additives		
$C_{10}H_{12}$ Dicyclopentadiene	0,1	Durability in a corrosive chemical environment, fire resistance, low water permeability
C_5H_6 Cyclopentadiene	1-30	
Olefin-polysulfide mixtures	5-25	
Bitumen	1-4	
Styrene	2-30	

2. Experimental evaluation of modified sulfur concrete.

We draw on the research below to quantify the environmental benefits of modified sulfur concrete. Sand and siliceous river gravel were taken as fine and coarse aggregates to obtain modified sulfur cement. Aggregates are subjected to a 24-hour chemical resistance test to determine their suitability for modified sulfur concrete. Sulfuric acid H_2SO_4 and ammonium sulfate SO_4 (NH_4) are added to the aggregates in a concentration of 40% to simulate industrial environment conditions. The fillers are preheated to 135°C in a temperature controlled mixer, then the sulfur and sulfur modifier mixture is added and the mixture is mechanically homogenized for about 20 minutes. The temperature in the mixer is always between 130 and 140 °C. After reaching this temperature, the modified sulfur mixture is ready and placed in the casting molds. To prepare the sample, cylindrical steel molds with a diameter of 15 cm and a height of 30 cm should be used, and the mixture should be preheated to 120 °C before pouring. Then the samples are compacted. The samples are allowed to cool to room temperature before removing them from the molds. [3]



The compressive strength of modified sulfur concrete is approximately 70% after casting and 75-85% after several hours. The durability of the obtained samples was evaluated by carrying out tests on 3, 7, 14 and 28 days. [6]

Currently, experimental experiments with modified sulfur are showing good results. All types of sulfur-asphalt concrete mixtures are prepared according to the requirements and technological regulations. For the preparation of mixtures, it is necessary to use gravel obtained in accordance with the requirements of RK ST 1284, GOST 8267, GOST 32703. Mineral powder - activated and non-activated, must meet the requirements of RK ST 1276, GOST 32761. The compressive strength of sulfur concrete is based on the following formula

Determined with an accuracy of up to 0.1 MPa:

$R=\alpha F/A$

where, α is the scaling factor for reducing the strength of sulfur concrete to the strength of sulfur concrete in samples of basic sizes and shapes, determined according to GOST 10180;

F – breaking load;

A – working cross-sectional area of the sample, mm2.

The strength of sulfur concrete in each series is determined as the arithmetic mean value of the tested samples. The water resistance of sulfur concrete W, % is determined by the following formula:

$W=(R_{20}^{w}/R_{20})*100$

where,R_{20}^{w} – Strength of sulfur concrete in water-saturated samples according to GOST 12730.3 and tested according to GOST 10180, MPa;

R_{20} – Strength of sulfur concrete in a series of control samples according to GOST 10180, MPa. [8]

In terms of classification, lightweight sulfur concrete is concrete with a sulfur binder and dense coarse and fine aggregates with an average density of 500 kg/m^3 to 2000 kg/m^3. Heavy sulfur concrete is a dense structure concrete with a sulfur binder and dense coarse and fine aggregates with an average density of 2000 kg/m$_3$ to 2500 kg/m$_3$. Specially heavy sulfur concrete is grouped as high-density structure concrete with sulfur binder and dense coarse and fine aggregates with an average density of 2500 kg/m^3. Concrete technology does not work without modifying additives. [4]

Sulfur concrete is produced and tested according to various foreign technologies. Since it is considered a material resistant to aggressive environment, Moscow, Ryazan, Volgograd, Irkutsk and Krasnoyarsk regions of Russia used it as a surface for road construction. Marine sulfur is used in a number of innovative projects. The Kazakh Oil and Gas Institute has developed a technology for the production of sulfur-containing composites and implemented a pilot project by producing pavers with an experimental unit and laying them on a part of the building. We can achieve economic efficiency by using sulfur and its compounds as raw materials for obtaining polymeric materials. It plays an important role in the successful implementation of nature protection activities. In compositions, sulfur plays the role of a polymer binder, such materials are polymer concretes, seroplasts.[8]

Sulfur concrete companies were established in the USA and Canada in the early 1980s, which were used as floor coverings in mineral acid factories. At the Norilsk mining and metallurgical plant of Russia "Spetsfundamentstroy" produced pavement tiles from sulfur concrete. Depending on the purpose of sulfur concrete fillers, quartz sand, crushed stone, acid-resistant silicate flour, ground coke or graphite powder, lime flour can be used.

The peculiarity of sulfur concrete is the ability to change its structure, remelt and reuse. Sulfur concrete is used not only in ready-made, but also in the production of monolithic structures, as well as in various repair works. In terms of chemical resistance and dielectric properties, they are not inferior to many types of polymer concrete, and in terms of cost, they are much lower than the cheapest ones. Currently, two main directions of sulfur use in construction have been identified. In Canada, bitumen-sulfur concrete is used for road surfaces. Such coatings are durable. Research conducted by Canadian firms and the US mining laboratory was engaged in the development of a technological regime for the preparation of mixtures. In addition, a lot of attention was paid to the placement of their layers, making maximum use of the bituminous binder, mixture preparation and modern serial equipment for road construction. Since the density of sulfur is much higher than the

density of bitumen, sulfur is used as an organic binder in the preparation of asphalt concrete mixtures. Currently, Poland is one of the world's leading sulfur producing countries. [7]
The need to make some changes to the traditional technology of sulfur asphalt concrete mixture preparation was proven by research conducted in Hungary. The results of these studies showed that the mixing of sulfur and bitumen should be carried out in mixing units that allow to achieve high homogeneity and uniformity of the mixture. In this case, the temperature of the mixture should not exceed 150°C, and the amount of sulfur should not exceed 20-25% by weight of the organic component. [5]

Conclusions

In conclusion, reusing sulfur can help reduce emissions to some extent. During the development of the Tengiz oil field in recent years, ten million tons of sulfur were found in the subsoil. As a result of the accumulation of sulfur, the ecological situation in the region deteriorates. Taking into account the increase in the volume of oil production in the Tengiz and other oil fields of the Caspian region, the problem of utilization of illiquid reserves of sulfur has a global character for Kazakhstan.

The country's connection to the North-South international transport network connecting India, Iran and Russia has led to the construction of long-distance highways. Huge investments were made for it. The regulatory frameworks necessary for the development of the technology of using sulfur concrete in road construction and conducting comprehensive research on adaptation to the environment have been developed, and the Government of the Republic of Kazakhstan has drafted a resolution to introduce this topic into the sectoral program of innovative development of the Ministry of Transport of the Republic of Kazakhstan. This draft resolution was agreed with the Minister of Energy and Mineral Resources of the Republic of Kazakhstan. Our President Kassym-Jomart Kemeluly Tokayev was nominated to the Government.

At present, it is a very important measure to support innovations in accordance with modern requirements and put them into production. It is impossible to develop new innovative sectors and create science-related industries without developing the domestic science industry. Innovative sector covers all areas of the economy. And it is known that their development often depends on scientific research and nanotechnology.

It is very important to adapt to foreign practices in the technological development of sulfur concrete production. Storage of sulfur in open blocks, above ground, has a negative impact on the environment. Open-type above-ground sulfur storage facilities are exposed to external destructive factors - changes in temperature and humidity, wind, precipitation, and can break into particles and form sulfur dust. In order to reduce the load on the environment, the production of concrete containing sulfur binder is considered one of the promising projects. Creating and developing a sub-industry of construction and road construction materials using sulfur as a binder is beneficial for the country's economy. It should be noted that sulfur concrete is stronger than ordinary concrete, due to the correct maintenance of the manufacturing process. It is of particular importance to create production facilities capable of producing a large volume of sulfur concrete while strictly observing technological standards.

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ТЕХНОЛОГИЯ ПРОИЗВОДСТВА КОМПОЗИЦИОННОГО МАТЕРИАЛА - СЕРОБЕТОННЫХ ИЗДЕЛИЙ ИЗ МОДИФИЦИРОВАННОЙ СЕРЫ

ЕСЕНАМАНОВА Ж.С., КАПИНА М.А.*

Есенаманова Жанар Санаковна — доктор PhD, и.о. доцента, Атырауский университет имени Халела Досмухамедова, Атырау, Казахстан;
E-mail: zhanyessen@mail.ru; https://orcid.org/0000-0003-3868-4092
***Капина Мадина Асетуллаевна** – магистрант 2 курса, ОП 7М05201- «Прикладная экология», Атырауский университет имени Халела Досмухамедова, Атырау, Казахстан;
E-mail: kapina.m01@mail.ru; https://orcid.org/0009-0006-7374-4723

Аннотация. Сера является одним из крупнотоннажных отходов в связи с увеличением переработки углеводородного сырья (нефти и газа), содержащего серу. Длительное хранение большого количества серы оказывает негативное воздействие на окружающую среду. Композиционный материал из модификации серы характеризуется экологической и экономической эффективностью в строительстве. В обзоре рассмотрены источники серы, ее свойства, технология производства серобетона, а также применение серобетона в современной строительной отрасли. Проведена экспериментальная оценка модифицированного серобетона, определены другие способы приготовления смесей, показана важность адаптации к зарубежному опыту в развитии производства серобетона. В целях снижения нагрузки на окружающую среду одним из перспективных проектов считается производство бетона, содержащего серное вяжущее. Ведь серобетон имеет такие преимущества, как устойчивость к кислоте и радиации, морозостойкость и возможность вторичной переработки. Целью работы было исследование нового состава серобетона на основе битумного компонента. Для исследования были подготовлены образцы серобетона с различным процентным содержанием компонентов.

Ключевые слова: серобетон, серобетонная смесь, модификация серы, химическая стойкость,

композиционный материал, химическая связка, заполнители, сероасфальтобетон.

МОДИФИКАЦИЯЛАНҒАН КҮКІРТТЕН КОМПОЗИЦИЯЛЫҚ МАТЕРИАЛ-КҮКІРТБЕТОН БҰЙЫМДАРЫН ӨНДІРУ ТЕХНОЛОГИЯСЫ

ЕСЕНАМАНОВА Ж.С., КАПИНА М.А.*

Есенаманова Жанар Санаковна - PhD доктор, доцент м.а., Халел Досмұхамедов атындағы Атырау университеті, Атырау, Қазақстан;
E-mail: zhanyessen@mail.ru; https://orcid.org/0000-0003-3868-4092
***Капина Мадина Асетуллаевна** - 7М05201- «Қолданбалы экология» ББ 2-курс магистранты, Халел Досмұхамедов атындағы Атырау университеті, Атырау, Қазақстан;
E-mail: kapina.m01@mail.ru; https://orcid.org/0009-0006-7374-4723

Аңдатпа: Құрамында күкірт бар көмірсутек шикізатын (мұнай-газ) өңдеу салаларының артуына байланысты күкірт- ірі тоннажды қалдықтардың бірі ретінде шығып жатыр. Үлкен көлемді күкірт қорын ұзақ уақыт сақтау қоршаған ортаға жағымсыз әсер береді. Күкірт модификациясынан шыққан композиттік материал-қоршаған ортаға экологиялық, құрылыста экономикалық тиімділігімен сипатталады. Бұл шолуда күкірттің шығу көздері, қасиеттері, одан күкіртбетон жасау технологиясы және күкірт негізіндегі бетонның бүгінгі күнгі құрылыс индустриясында қолданылуы зерттеледі. Модификацияланған күкіртті бетонды эксперименттік бағалап, қоспаларды дайындаудың өзге әдістері анықталды, күкіртті бетон өндірісін дамытуда шетелдік тәжірибелерге бейімделудің маңыздылығы көрсетілді. Қоршаған ортаға жүктемені азайту мақсатында күкіртті байланыстырғыштан тұратын бетон шығару- келешегі бар жобалардың бірі болып саналады. Өйткені, күкіртбетонның қышқыл мен радиацияға, аязға төзімділігі және қайта өңдеу мүмкіндігі сияқты артықшылықтары бар. Жұмыстың мақсаты битум құрамдас негізіндегі күкіртті бетонның жаңа құрамын зерттеу болды. Зерттеуді жүргізу үшін құрамдас бөліктердің әр түрлі пайыздық құрамы бар күкіртті бетон үлгілері дайындалды.

Түйін сөздер: күкіртбетон, күкіртбетон қоспасы, күкірт модификациясы, химиялық төзімділік, композиттік материал, химиялық байланыс, толтырғыштар, күкірт асфальтбетон.