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STUDY OF THE PROCESS OF OBTAINING MODIFIED SULFUR CONCRETE BASED ON LOCAL RAW MATERIALS AND STUDY OF RADIONUCLIDES OF SULFUR CONCRETE AND PORTLAND CEMENT

Abstract*: The article explores the process of obtaining modified sulfur concrete based on local raw materials and the study of radionuclides of sulfur concrete and Portland cement. The novelty of the work was determined by the amount of radionuclides Ra-226, Th-232, K-40 in sulfur concrete and Portland cement. Considering the advantage and convenience of sulfur concrete, it was analyzed on a gamma spectrometer. Accordingly, the test conditions are: T-22°C, humidity -63%, illumination-300 lux, specific activity Bq /kg. According to SanPiN 0193-06, they are used in construction at a level of less than 350 Bq / kg. In the analysis of sulfur concrete, its radionuclides averaged 127 Bq /kg. Sulfur concrete contains modifier-26%, sand-54%, ash (ash) -16% and various metal oxides -4%. Additives and fillers added to sulfur concrete, ie radionuclides in sand and gravel were analyzed using gamma spectrometry.*

Key words*: Sulfur, modified sulfur, crotonic aldehyde, modification, gamma spectrometer, sulfur concrete.*
Language*: English*

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Introduction

The consumption of fossil fuels is growing rapidly around the world, as is the amount of sulfur that is formed as a by-product of the process of industrial purification of fuel raw materials. Since the sulfur content is expected to increase steadily in the future, huge waste disposal costs will be required in the absence of a counter plan. Therefore, when modifying sulfur, it is important to synthesize sulfur-containing binders and obtain new types of modified sulfur concrete on their basis in order to obtain durable building materials, such as asphalt and concrete, resistant to various aggressive environments.

Today, in the industrialized countries of the world, much attention is paid to research aimed at obtaining modified sulfur concrete and its use to increase the strength of building structures. Therefore, the development of organic modifiers for the effective polymerization of sulfur, the production of thermoplastic composites based on sulfur and mineral fillers, the prevention of solid-phase transitions and volume reduction due to temperature changes in sulfur concrete , the elimination of the combustibility of compositions based on modified sulfur, it is required to develop effective methods for obtaining durable polymeric sulfur concrete stable at high concentrations of acids and salts based on modified sulfur with unsaturated organic compounds.

Certain scientific and practical results have been achieved in the republic on the creation of sulfur binders and sulfur concretes based on modified sulfur and sulfur waste from the gas and oil processing industry. On the basis of the normative measures taken in this direction, certain results have been achieved, especially in the development of scientific foundations for the production of polyfunctional compositions, large-scale measures have been taken in the field of providing the local market with imported products.

Portland cement requires limestone to be heated in kilns at over 1400 $^{\circ}$ C for several hours to form clinker materials. Due to the fact that fossil fuels are burned to fire kilns and the stoichiometric release of carbon dioxide when limestone is converted to calcium oxide, this process generates about one ton of carbon dioxide for every ton of cement and accounts for 5% of global anthropogenic $CO_{2\ production}$ [1; pp . 303-329, 2]. Unlike traditional cement production, sulfur-based cement production does not depend on high energy or direct carbon dioxide emissions [3 , 4; pp. 159-175, 5]. In addition, sulfur is in net excess on a global scale. Sulfur is the third most common chemical element in oil at concentrations greater than 10 wt %, and its extraction from oil and gas processing is carried out in accordance with environmental restrictions [6 ; pp. 53-57]. Thus, a large amount of sulfur is available as a by-product of these processes [3]. Also, since sulfur itself is an industrial by-product, a significant amount of carbon dioxide emissions can be reduced by using sulfur-based concrete. Sulfur-based concrete is a thermoplastic composite of mineral fillers and sulfur. Early studies using elemental sulfur have shown that it has serious durability issues such as repeated freeze and thaw cycles [7, 8; pp. 606-621, 9; pp. 363-367, 10 ; pp. 31-53]. When sulfur and filler are hot mixed and cooled to cast sulfur concrete products, the liquid sulfur binder initially crystallizes into monoclinic sulfur (S_b). As it continues to cool, the material undergoes a solid phase transition to rhombic sulfur (S_a), which causes the material to shrink in bulk. This decrease in volume creates internal stress and causes durability problems, especially when subjected to freeze cycles. Therefore, chemical modifiers that polymerize sulfur to reduce or eliminate solid state transition and thus increase the durability of sulfur-based concrete have been previously studied [3; 11 ; pp. 186-194 , 12 ; pp. 27-38]. This modified sulfur concrete is called polymeric sulfur concrete (PSB). It has been used as a building material due to its excellent resistance to acid and salt environments. It is also known that this binder effectively stabilizes /hardens contaminated soils [13; pp. 441-447 , 14 ; pp. 327-333] or nuclear waste [4 ; pp. 159-175 , 15; 16]. Unlike conventional hydraulic cementitious concretes, PSB does not require water and can reach full strength in a matter of days, compared to 28 days for conventional Portland cement based concretes.

Several organic chemical modifiers have been developed to polymerize sulfur efficiently. Commonly used modifiers are dicyclopentadiene (DCPD), a combination of DCPD, cyclopentadiene and dipentene [10 ; pp. 31-53 , 17 ; pp. 105-113 , 18 ; pp. 13-18], olefinic polysulfide [9 ; pp. 363-367] and 5-ethylidene-2-norbornene (ENB) and/or 5-vinyl-2-norbornene (VNB) [3]. When treated with molten sulfur, the unsaturated hydrocarbons in the organic modifiers break down liquid $S8_{rings}$ and react to form long chain polymers. Polymerized linear sulfur chains improve durability. Although modified concrete is environmentally sustainable and durable, the high cost of these organic modifiers has prevented its widespread use in the construction industry [11 ; pp. 186-194].

Sulfur has been used as a molten binding agent for quite some time in human history. The use of sulfur was mentioned in the literature of Ancient India, Greece, China and Egypt [19 ; pp. 15-17]. For example, sulfur was one of the raw materials for the production of gunpowder by the ancient Chinese [20]; sulfur was also used to fix metal in stone in the 17th century [21]. Since the 1920s, sulfur concrete has been used as a building material [22]. Various researchers and engineers studied and managed to obtain high-strength and acid-resistant sulfur concrete [23; pp. 65-72, 24; pp. 1026-1028, 25 ; pp. 583-586]. In the late 1960s, Dale and Ludwig pointed out the importance of well graded aggregates for optimum strength [26, 27].

Considering the advantage and convenience of sulfur concrete, we analyzed it on a gamma spectrometer . Accordingly, test conditions: T-22 °C , humidity -63%, illumination-300 lux, specific activity Bq/kg.

0193-06, they are used in construction at a level of less than 350 Bq / kg. In the analysis of sulfur concrete, its radionuclides averaged 127 Bq/kg. Sulfur concrete contains a modifier - 26 %, sand - 54 %, ash (ash) - 16 % and various metal oxides - 4 %. Additives and fillers added to sulfur concrete, i.e. radionuclides in sand and gravel were analyzed using gamma spectrometry . Accordingly, test conditions: T-22`C, humidity -63%, illumination-300 lux, specific activity Bq / kg (tables 1.1 - 1.4) [28 ; pp. 202-205].

Table 1.1. Analysis of radionuclides in sulfur concrete using a gamma ray spectrometer.

Name	Ordinal room sample	Ra-226	Th-232	K-40	Aeff .	Aeff.m
sulfur concrete	1	9.11	36.9	84.1	64.6	136
	2	10.2	35.1	84.7	63.4	130
	3	14.0	29.5	85.7	59.9	119
	4	11.2	36.2	82.5	65.6	128
	5	18.1	31.8	84.0	66.9	122
	Medium _	12.5	33.9	84.0	Aeff avg = 64.08	Aeff . m medium=127 Bq / kg

Table 1.2. Analysis of radionuclides in sand with a gamma ray spectrometer.

Name	Ordinal room sample	Ra-226	Th-232	K-40	Mistake detection , %	Aeff . Bq / kg
Sand	1	20.9	6.86	25.3	6.2-10.8%	91.1
	2	22.6	3.86	25.9	6.2-10.9%	122
	3	19.5	5.87	27.5	5.8-10.3%	97.6
	4	21.3	4.12	26.4	6.0-10.4%	114
	5	21.1	4.47	25.1	6.1-10.2%	109
Aeff.m = 107 Bq / kg						

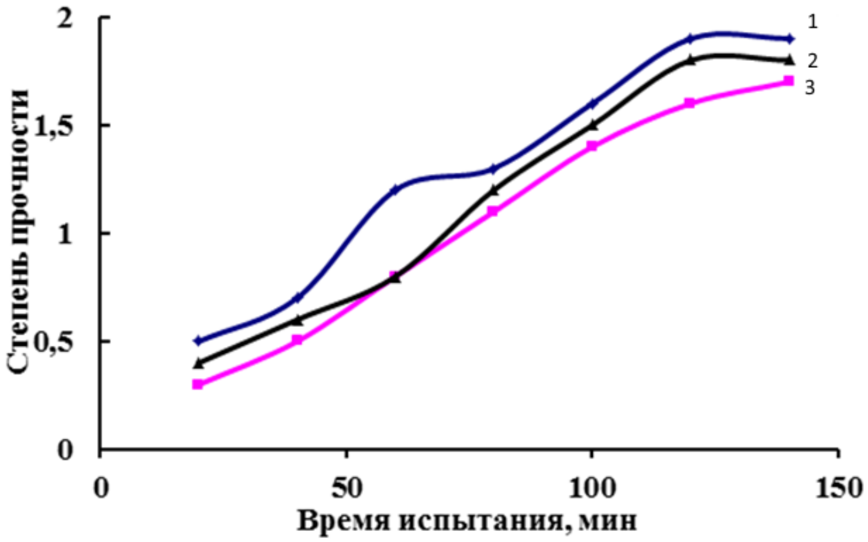
Table 1.3. Analysis of radionuclides in "rubble" on a gamma spectrometer.

Name	Ordinal room sample	Ra-226	Th-232	K-40	Mistake detection , %	Aeff . Bq / kg
rubble	1	20.3	5.17	25.9	6.2-10.8	103
	2	20.5	4.02	49.8	6.2-10.9	175
	3	19.6	4.03	27.9	5.8-10.3	114
	4	17.8	5.49	39.9	6.0-10.4	96.4
	5	20.6	3.28	41.3	6.1-10.2	129
Aeff.m = 123.48 Bq / kg						

Portland cement M-500 was also analyzed on the MKS -AT-1315 gamma spectrometer. Accordingly, test conditions: T-22 °C, humidity -63%, illumination-300 lux, specific activity Bq/kg. In addition to the detection of sulfur concrete mixtures, various fine aggregates such as "fine sand", "washed sand" and manufactured sand replacing 0%, 25%, 50%, 75% and 100% sulfur concrete were also studied in the above study. The durability of each type of fine-grained sulfur concrete with the best compressive strength has been studied [29 ; pp. 34-39].

Table 1.4. Analysis of radionuclides in Portland cement M-500 on a gamma spectrometer .

Name	Ordinal room sample	Ra-226	Th-232	K-40	Mistake detection , %	Aeff . Bq / kg
Portland cement M-500	1	27.5	5.68	25.0	62.5	112
	2	24.0	7.37	24.2	73.4	97.3
	3	22.8	5.42	24.4	74.6	103
	4	21.3	2.93	36.0	68.9	133
	5	20.2	3.00	22.5	67.8	125



1 - Crushed stone, 2 - Portland cement, 3 - Sulfur concrete
Fig. 1 . The level of strength of concrete obtained on the basis of sulfur concrete , sand, crushed stone and Portland cement M-500.

This graph tests the strength of concrete based on sulfur concrete , sand, crushed stone and Portland cement M-500. It is shown that the strength of sulfur concrete does not differ from the strength of other types of concrete. To determine the superiority of sulfur concrete over cement concrete, water absorption, resistance to various chemical environments, and rapid penetration of chloride ions were tested. The result shows that sulfur concrete can be used in rooms with high humidity, where acid activity is higher. Sulfur concrete gives a result similar to ordinary concrete (Fig. 1). Another advantage of sulfur concrete is that any fine aggregate can be used as aggregate in sulfur concrete, as it is a waterproof type of concrete.

Thus, the results of gamma spectrometric studies carried out on all of the above samples comply with the requirements of sanitary regulations No. 0193-06. The results obtained can be used in housing construction with a gamma spectrometer up to 300 Bq/kg. If <350 Bq/kg, it can be used for street fences, ditches, underground pipe protection devices, paved roads (Paving stones)[30 ; pp. 202-205].

References:

1. Worrell, E., Price, L., Martin, N., Hendriks, C., & Meida, L.O. (2001). Carbon dioxide emissions from the global cement industry 1, *Annu. Rev. Energy Environ*, 26 (1), 303-329.
2. Agency, I.E. (2009). Cement technology roadmap 2009, carbon emission reductions up to 2050, *World Bus. Counc. Sustain. Dev*., www.ieaorg.
3. Mohamed, A. M. O., & El-Gamal, M. (2010). *Sulfur concrete for the construction industry: a sustainable development approach*. J. Ross Publishing.

4. Mohamed, A. M. O., & El Gamal, M. (2007). Sulfur based hazardous waste solidification. *Environmental geology*, *53*(1), 159-175.
5. Kalb, P. D., Heiser III, J. H., Pietrzak, R., & Colombo, P. (1991). *Durability of incinerator ash waste encapsulated in modified sulfur cement* (No. BNL--45292). Brookhaven National Lab.
6. Waldo, G. S., Mullins, O. C., Penner-Hahn, J. E., & Cramer, S. P. (1992). Determination of the chemical environment of sulphur in petroleum asphaltenes by X-ray absorption spectroscopy. *Fuel*, *71*(1), 53-57.
7. (1988). 548 AC, Guide for mixing and placing sulfur concrete in construction, (1988) *ACI Mater. J.* 85 (4).
8. Vroom, A. (1992). *Sulfur polymer concrete and its application, in*: Proceeding of Seventh International Congress on Polymers in Concrete, 606-621.
9. Nnabuife, E. L. C. (1987). Study of some variables affecting the properties of sulfur-reinforced sugarcane residue-based boards. *Indian Journal of Technology*, *25*(8), 363-367.
10. Bordoloi, B. K., & Pearce, E. M. (1978). *Plastic sulfur stabilization by copolymerization of sulfur with dicyclopentadiene.*
11. Mohamed, A. M. O., & El Gamal, M. (2009). Hydro-mechanical behavior of a newly developed sulfur polymer concrete. *Cement and Concrete Composites*, *31*(3), 186-194.
12. Mohamed, A., El Gamal, M., & El Saiy, A. (2006). *Thermo-mechanical Performance of the Newly Developed Sulfur Polymer Concrete.* Reclaiming the Desert: towards a Sustainable Environments in Arid Land, Developments in Arid Region Research (DARE), Taylor and Francis Group, London, 27-38.
13. Lin, S. L., Lai, J. S., & Chian, E. S. (1995). Modifications of sulfur polymer cement (SPC) stabilization and solidification (S/S) process. *Waste management*, *15*(5-6), 441-447.
14. Fuhrmann, M., Melamed, D., Kalb, P. D., Adams, J. W., & Milian, L. W. (2002). Sulfur polymer solidification/stabilization of elemental mercury waste. *Waste Management*, *22*(3), 327-333.
15. Kalb, P. D., Heiser III, J. H., & Colombo, P. (1990). *Comparison of modified sulfur cement and hydraulic cement for encapsulation of radioactive and mixed wastes* (No. BNL-45163; CONF-9008119-2). Brookhaven National Lab., Upton, NY (USA).
16. Darnell, G. R. (1991). *Sulfur polymer cement, a new stabilization agent for mixed and Low-level radioactive waste* (No. EGG-M-91419; CONF-910840-11). EG and G Idaho, Inc., Idaho Falls, ID (United States).
17. Currell, B. R. (1976). The importance of using additives in the development of new applications for sulfur. In *Symposium on new users for sulfur and pyrites, Madrid* (p. 105e113).
18. Beaudoin, J. J., & Feldman, R. F. (1984). Durability of porous systems impregnated with dicyclopentadiene-modified sulphur. *International Journal of Cement Composites and Lightweight Concrete*, *6*(1), 13-18.
19. Sheppard Jr, W. L. (1975). Sulphur Mortars: A Historical Survey. *Sulphur Institute Journal*, *11*(3/4).
20. Buchanan, B. J. (Ed.). (2006). *Gunpowder, explosives and the state: a technological history*. Ashgate Publishing, Ltd..
21. Rybczynski, W. (1974). *Sulphur concrete and very low cost housing*.
22. (1998). *Guide for Mixing and Placing Sulfur Concrete in Construction*, (1998) ACI 548.2R-93.
23. Bacon, R. F., & Davis, H. S. (1921). Recent advances in the American sulphur industry. *Chem. Metall. Eng.* 24(2) 65–72.
24. Kobbe, W. H. (1924). New Uses for Sulfur in Industry. *Industrial & Engineering Chemistry*, *16*(10), 1026-1028.
25. Duecker, W. W. (1934). Admixtures improve properties of sulfur cements. *Chemical and Metallurgical Engineering*, *41*(11), 583-586.
26. Dale, J. M., & Ludwig, A. C. (1966). *Feasibility study for using sulphur aggregate mixtures as a structural material*. Southwest Research Inst San Antonio Tx.
27. Dale, J. M., & Ludwig, A. C. (1968). *Advanced studies of sulphur-aggregate mixtures as structural materials*. Southwest Research Inst San Antonio tx. 68.
28. Amanova, N.D., Tўraev H.H., & Beknazarov, H.S. (2020). Sintez i issledovanie novogo polimernogo serobetona. Universum: tehnicheskie nauki: nauchnyj zhurnal. Chast` 3.M., Izd. «MCNO», 6 (75), pp.5-8.
29. Amonova, N.D., To'raev, X.X., & Eshqurbonov, F.B. (2020) Oltingugurtli beton tarkibidagi radionukleidlarni gamma spektrometr yordamida tahlil qilish. *O'zbekiston Kompozitsion materiallar ilmiy-texnikaviy va amaliy jurnali*, 3, 202-205.
30. Amonova, N.D., To'rayev, X.X., & Eshqurbonov, F.B. (2020) Gamma spektrometr yordamida oltingugurtli beton tarkibini fizik-kimyoviy tahlil qilish. *Fan va texnologiyalar taraqqiyoti*, 6, 34-39.