

Development of the Structure of Road-Construction Materials with the Use of Drilling Cuttings

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Abstract

Oil based drilling cuttings after thermal treatment processed at 340 °C were used as mineral powder for creation of composite material. For a compounding of drilling cuttings the road asphalt of the BND 60/90 brand was used. Efficient activity of natural radio nuclides which made 25 ± 5 Bq/kg was identified. Element structure of drilling cuttings was identified with the usage the method of the X-ray phase analysis. Existence of the signal corresponding to the following connections was established: CaCO_3 – calcite, NaCl – halite, BaSO_4 – barite, $\text{CaMg}(\text{CO}_3)_2$ – dolomite. Content of calcite makes 65% of masses, content of halite – 15% of masses, content of dolomite – 8% of masses, content of barite – 10% of masses. A small amount of organite (CaCO_3), anhydrite (CaSO_4) and quartz (SiO_2) was discovered. Formation of series of test samples of composite material with the subsequent research of their physical and chemical and operational properties was done. The most optimum is the asphalt concrete mixture with the content of 7% of drilling cuttings as mineral powder. Physical and chemical characteristics of the made samples indicate compliance to qualifying standards. The received results allow recommending drilling cuttings after thermal treatment as a mineral additive at construction of highways of IV-V technical category. The use of oil based drilling cuttings as a mineral component of road-building coverings does not constitute ecological danger to the environment, thereby, it gives the chance to solve one of the urgent environmental problems of the region, i.e. the effective use of industrial wastes and environment protection.

Introduction

The oil-extracting and oil-processing industry plays now a huge role in economy of the Republic of Kazakhstan. Annually accumulated oil wastage at a lack of necessary methods of their utilization and processing leads to withdrawal of land resources on the long terms.

Major threats to the natural environment are industrial and technological drilling waste that accumulate and are stored directly on the drilling site. They contain a wide range of contaminants of mineral and organic nature, provided materials and chemical reagents used for the preparation and handling of drilling fluids.

Drilling cuttings in the majority consist of drilling rock (clay and sand particles) on 30-45% of masses, 30–45% of drilling solutions and 10–20% of possible technologic discharges, underground waters and oil. Drilling solutions, in turn, consist of water – 85-

89%, bentonitic dry muds – 10-11%, the rest 1-5% can contain various greasing, antiseptic, defoaming, anti-filtration and oil wetting liquids [1, 2].

In paper [3] composite materials, constructions, ways of construction of highways with application of composite materials on the basis of soil and drilling wastage are developed. According to authors it allows reducing the need for imported road-construction materials, efficient utilization and neutralization of wastage of drilling.

Suitability of oil wastes as technogenic raw materials is identified during the complex analysis.

In papers [4-7] for road construction the mixture with the following structure is recommended (%): soil – 75 ... 85; lime – 4 ... 5; oil cuttings – 2 ... 4; water – 8 ... 16.

Oil cutting are used as connecting, rising durability, reducing the water absorption, reducing paving cost of road coverings.

In paper [8] for strengthening of the ground

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polluted by organic compounds, the technology of stabilization of ground with bituminous emulsion is applied. The stabilizing environment of process is the bituminous emulsion, containing water, surface-active substances and bitumen.

The description of new process (PST) of processing of the oil cuttings is provided in paper [9], allowing to reduce quantity of toxic waste on 85% and to receive a marketable products. Processing is carried out at 300-350 °C and pressure of 98-175 atm. with receiving oil, water from solid waste.

Material and Methods

Oil based drilling cuttings after thermal treatment at 340 °C were used as mineral powder for creation of composite material. For a compounding of drilling cuttings road asphalt of the BND 60/90 brand was used.

The thermogravimetric analysis of object was made on a derivatograph providing precise filing of all phase changes of the first sort, kinetic constants of processes. Heat rates of samples varied from 2.5 to 20 °C/min.

The method of X-ray fluorescence analysis was applied to identification of element structure of samples. The qualitative and quantitative structure of studied samples on elements beginning with (11Na) to (92U) was carried out on a power dispersion fluorescent x-ray spectrometer of EDX-720 (SHIMADZU, Japan) using cuvette method. The analysis of samples was carried out using method of fundamental parameters in the atmosphere of air and in the conditions of a high vacuum.

Identification of radioactive nuclides (strontium and cesium) was carried out according to GOST 30108-94.

For identification of existence of crystal phases the X-ray phase analysis of object is carried out. Shooting of diffractograms was carried out using diffractometer DRON-5 working at $FeK\alpha$ – radia-

tion. The shooting interval on reflex angles made 15-95°, speed – 2 hails/min. In some cases the speed of shooting was 1.0 hails/min.

Studying of physicomechanical properties of mixtures of asphalt concrete was carried out according to GOST 12801-98.

Results and Discussions

For identification of safety of a drilling cuttings at creation of composites materials at construction of highways efficient activity of natural radionuclides which made 25 ± 5 Bq/kg, at norm no more than 740 Bq/kg was identified.

For the purpose of studying of possibility of the use of drilling cuttings in creation of composites in construction of highways thermogravimetric researches of samples of a fixed residue post thermal treatment of oil based drilling cuttings were conducted at temperature 340 °C.

It was established that heating of the sample received by post thermal treatment at 340 °C, above 60 °C leads to weight loss in 11% of masses. This process is accompanied by endothermal effect with a maximum on a curve differential thermal analysis at 120 °C. In the range of temperature 300-360 °C on a curve differential thermal analysis very weak effects were noted, evidently was bound to oxidation of small amounts of organic compounds. Above 400 °C there is a sluggish decrease of weight at the expense of thermal decomposition of carbonaceous components (Fig. 1).

The method of X-ray fluorescence analysis was applied to identification of element structure of samples. The element structure of a product of thermolysis of drilling cuttings is presented in Table 1. Source of barium is the barium sulphate used as a part of initial drilling solution as a weighting material. Calcium gets to drilling cuttings as a result of drilling of carbonate layers of rock and, partially, at a cementage of wells.

Table 1
Element structure of residue of burning of oil based drilling cuttings

Element	Al	Na	K	Si	SiO ₂	Fe ₂ O ₃	CaO	Ba	S	Sr
Mass fraction, %	0.9	6.3	0.8	3.9	2.1	0.2	49.9	31.8	2.8	0.9

In drilling cuttings there are such elements as zinc, chrome, nickel within $3 \cdot 10^{-4}$ - $1 \cdot 10^{-5}$ %.

For the purpose of identification of crystal phases of residue of drilling cuttings the X-ray phase analysis of objects was carried out. Identification of phases was carried out according to a card file according to

the Diffraction Analysis of Powder of the International Center for the Diffraction Data (JCPOS).

Existence of the signal corresponding to the following connections was established: CaCO₃ – calcite, NaCl – halite, BaSO₄ – barite, CaMg(CO₃)₂ – dolomite. Content of calcite of 65% of masses,

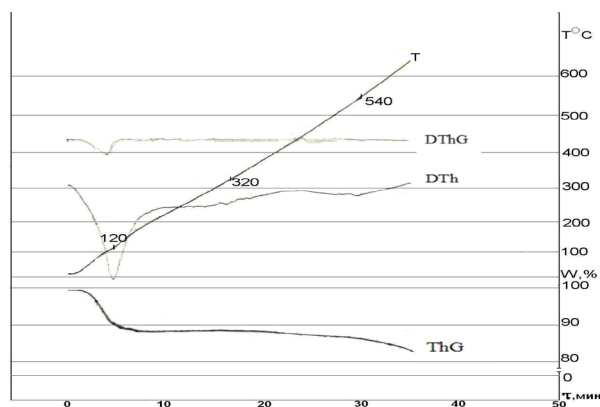


Fig. 1. Results of thermogravimetric research of the rest of thermolysis of drilling cuttings at 340 °C.

halite – 15% of masses, dolomite – 8% of masses, barite – 10% of masses. A small amount of organite (CaCO₃), anhydrite (CaSO₄) and quartz (SiO₂) was recorded (Fig. 2).

Rocks which contain carbonate are most often used as mineral additives at construction of highways [10].

The identified structure of the thermal residue of drilling cuttings allows to make the conclusion about possibility of its use as one of components of construction composites materials. For the solution of this task selection of optimum and efficient structure of an asphalt concrete mixture was carried out.

For preparation of asphalt concrete mixtures in laboratory the samples containing as a mineral additive of 5-8% of drilling cuttings were prepared.

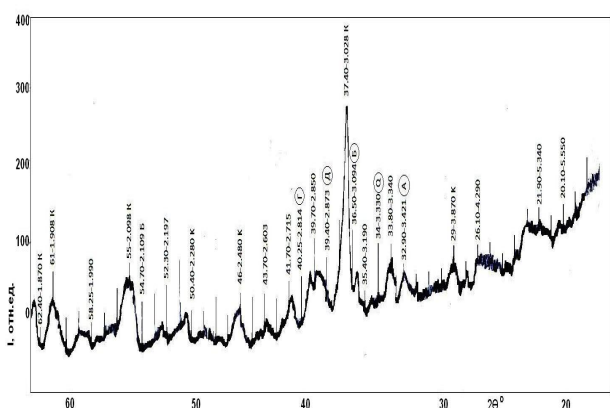


Fig. 2. The roentgenogram of residue of burning of oil based drilling cuttings.

Test of physicomechanical properties of asphalt concrete mixture was conducted: compressing strength, MPa, at temperature 20 °C, 50 °C, 0°C, water resistance coefficient, water saturation.

Research showed that the most optimum is the asphalt concrete mixture with the content of 7% of drilling cuttings as mineral powder. The received results are presented in Tables 2 and 3.

Table 2

Structure of asphalt concrete mixture with the content of mineral powder of 7%

Compound	
Macadam	46
Siftings	37
Sand	12
Powder tested (drilling cuttings)	7
Bitumen	6

Table 3

Physicomechanical characteristics of asphalt concrete compound

	Compound				
	20 °C	50 °C	0 °C	W	K _{water}
Actual indications, %	3.73	1.87	7.61	3.27	0.86
Requirements of ST RoK 225-2003	no≤2.2	no≤1.2	no≥13	1.5-4.0	no≤0.80
W – water saturation, K _{water} – water resistance coefficient					

The analysis of physical and chemical characteristics of the made sample indicates compliance to GOST(state standard specification requirements).

Conclusions

On the basis of physicomechanical properties of asphalt concrete compound it was established that optimum and efficient structure is the asphalt concrete compound with the contents as mineral powder of 7% of drilling cuttings.

The received results allow to recommend drilling cuttings post thermal treatment as a mineral additive at construction of highways of IV-V technical category.

The use of oil based drilling cuttings as a mineral component of road-building coverings does not constitute ecological danger to the environment, thereby, it gives the chance to solve one of urgent environmental problems of the region – effective use of industrial wastes and environment protection.

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