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Development of Technology for Disposal of Drilling Wastes Offshore Oil and Gas Facilities

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Abstract. It is proposed to use a new method for disposing of drill cuttings by formation of concrete blocks and their subsequent storage on the sea bottom, where they will be used as building materials or serve as artificial reefs. Volgograd State Technical University carried out experiments on the possibility of making concrete blocks for platform based drill cuttings having mechanical and environmental properties required for storage at the sea bottom.

1. Introduction

Currently, there are 3 types of drilling waste management on offshore platforms:

- direct discharge into the sea
- injection into permeable layers
- removal of drilling waste on land

Each method has serious drawbacks and limitations. Direct discharge of products into the sea is the cheapest and it has been widely practiced in offshore drilling. Drilling sludge is usually contaminated with oil and toxic substances, which are added to the washing liquid [1-3]. Therefore, at present, the disposal of waste on the continental shelf is allowed only in accordance with Federal law and with ensuring reliable localization of buried waste and other materials.

Quite widely advertised method of disposal of drilling waste by pumping them into underground permeable horizons or underground tanks formed by fracturing. The process provides a high speed of waste treatment and is very compact and easy to maintain with the existence of appropriate geological conditions and compliance with the necessary rules for such an operation.

The principle of "zero discharge", which is used in Maritime operations in the Caspian sea, involves the removal of drilling waste on land, followed by their safe disposal. The method is practically inapplicable in the conditions of development of the Arctic shelf due to the long ice conditions that prevent regular transport of waste.

Under these conditions, it is proposed to use a new method of utilization of drilling slurries by forming concrete blocks, followed by their storage at the bottom of the sea. It is assumed that granular drilling waste will be processed in the monolithic concrete blocks on a technology platform, followed by storing them close to the technological platforms, where they will be used as building materials or serve as artificial reefs. The technology should be adapted to the conditions of offshore platforms and meet the technological and environmental requirements of offshore operations.



2. Relevance

For the first time the experience in the construction of artificial reefs began to be used in the West in the 90-ies of the last century. During the disarmament period, such spawning grounds were built of war scrap: tanks and boats. In 1999, the US army transported to the sandy bottom of the Gulf of Mexico three thousand old tanks, a few miles South of the Florida Keys at a depth of about 18 meters lies the tug boat "Miss Louise". This ship was sunk intentionally and became part of the state program "Artificial reef", which is the Florida state spends \$600 thousand. There, near the Islands of Florida Keys, at a depth of 40 m is decommissioned military destroyer, which was also deliberately flooded. According to scientists, within five years the skeleton of the flooded ship would be completely covered by corals and would become the basis for a new sea reef – the largest artificial reef in the world. The Americans for the construction of reefs in the course is everything: school buses, New York subway cars and concrete blocks.

In the UK, the Scottish Association for marine research off the West coast of Scotland, near the island of Lismore, was built a concrete shelter for fish. This place was chosen deliberately, because there was almost no fish in the area, but it came here a year after the construction of the barrier reef. For the construction of 7 artificial reefs used concrete blocks weighing up to 40 kg, which now serve as fish cover. By the time of completion of the project in 2005, the British plan to install more than a million such blocks.

Abandoned oil platforms also serve as reefs. A number of observations showed that where there is a platform, on a flat sandy bottom after a while, cancers appear and an artificial spawning ground begins to form. For example, the operating drilling fourth largest in Europe Italian oil company Eni SpA, located 400 meters from the shore near the resort area, fish lives right next to the platforms. For the same reason, the construction of false reefs took the form of public policy in Japan.

In the mid-1970s, in the USSR the study of artificial reefs was included in the state project "Reef" standing as one of the project "Space". Every year, several million rubles were allocated from the state budget. In the 80s, an experimental scheme was first applied on the Azov sea: a solid substrate of any cast of material-building waste – was lowered to the bottom. For example, in a certain form (post-test were best recognized by the shape of the pyramid) are installed normal tires. Plantation - a hundred of these "pyramids" of tires at a depth of five to ten meters - during the year overgrown with shellfish and algae, forming an artificial spawning ground for fish. Formative type of Azov artificial reefs became mussels, the rate of growth and development of which in the new conditions was extremely high. Established in 1990 in the Berdyansk Gulf a few small experimental reefs-biofilters increase in the catch of fish dramatically. In General, scientists predicted the probability of increasing the fish population on the artificial reef a hundred times compared to that in the surrounding waters. However, the Reef project was closed in 1991.

On long-term observations of specialists of Institute of Biology of the Sea of DVO RAS, artificial reefs are able to significantly increase the productivity of coastal waters and fish catches, without significant costs. Their exposure at depths up to 20 m should become a national task of Russia. Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented.

3. Setting of the problem

For the manufacture of blocks from which the reefs will be formed, it is necessary to develop technology for processing sludge, one of the areas could be dewatering and thermal drying (sintering) of drilling sludge to form a ceramic mass. Experiments on the production of porous aggregate using drilling sludge gave the material with bulk density of 340-420 kg / m³, with compressive strength of 2.2-2.8 MPa and frost resistance of 16-22 cycles [4]. The direct use of such material in the reef building is impossible due to its low density.

Specialists at the Volgograd State Technical University carried out experiments on the possibility of making concrete blocks based on drill cuttings having mechanical properties required for storage at sea [5-12]. For experiments, drilling sludge obtained from drilling wells in the Caspian Sea and

onshore wells of the Astrakhan region with preliminary purification from petroleum products was used.

Three types of sludge were studied:

- sludge with a high content of sand, up to 90% and with a content of small fractions up to 50 microns;
- sludge with the content in its composition more than 80% of dolomite and limestone.
- sludge with clay content up to 90%.

4. Theoretical part

Based on the analysis of the phase, granulometric and component composition of the drilling sludge were found principal solutions for the use of drilling sludge in the production of building materials, as well as in the manufacture of marine structures in the form of containment malls, ballasting coatings underwater pipelines, etc.

On the basis of the conducted preliminary studies to determine the mineralogical and chemical composition of drilling sludge is proposed to use the waste products with content of sand up to 90% while obtaining fiber-reinforced concrete mixtures. Fiber reinforcement contributes to the resistance of concrete to aggressive environment, reduces the thickness of structures and significantly reduces or completely eliminates the consumption of reinforcement. The objective of the research is to improve the efficiency of the process of preparation of modified concrete mix, aimed at increasing its compressive and tensile strength during bending by using components that strengthen the structure of the fiber concrete at the macro and micro levels [13-19].

With formulation development of fiber-reinforced concrete as a binder used Portland cement M 500 DO. The dried and crushed drilling slurry waste acted as a small filler.

To increase the density, strength and fracture toughness of fiber reinforced concrete on the macro level, applying steel fiber-fiber "Mixarm" with cone-shaped anchors at the ends is based on a steel wire produced by JSC "Severstal - metiz" on TR 1211-205-46854090-2005.

To reduce the consumption of expensive steel fiber, dispersed reinforcement in the form of basalt fiber with a diameter of 13-17 μm and a length of 6-12 mm with tensile strength up to 2000 MPa was additionally used [20]. The amount of injected expensive steel fiber was reduced by 1.5 times, and the consumption of basalt fiber did not exceed 1.3 kg/m^3 , which is no more than 250 rubles per 1 m^3 of the mixture.

To strengthen the structure at the micro level, superplasticizer "Polyplast SP-3" was introduced into the mixture, which is a brown powder that complies with the requirements TR 5870-006-58042865-05 [21]. It can significantly increase the mobility of the mixture while reducing the water-cement ratio and increase the density, strength and frost resistance of fiber reinforced concrete.

5. Results of experiments

For determination of mechanical properties from concrete mix prepared samples-cubes of the size 10x10x10 cm and samples-beams of the size 40x40x160 mm by a standard technique (see Figure 1) hardening in natural condition, and tested for durability and frost resistance.



Figure 1. Samples of fiber-reinforced concrete using drilling sludge.

The test results are presented in table 1.

Table 1. Physic-mechanical properties of fiber reinforced concrete using drilling sludge.

Compositions of proposed concrete mix	Tensile strength at compression, MPa	Tensile strength at bending, MPa	Frost resistance, cycles
№ 1	50,34	6,0	300
№ 2	55,08	6,8	365
№ 3	56,16	7,1	400

The analysis of the presented data shows that the introduction into the concrete mixture of steel and basalt fibers, drilling sludge waste contributes to the production of concrete with high values of density, compressive strength and bending strength, as well as high frost resistance.

6. Conclusions

Thus, at present, fundamentally new approaches to the use of drilling slurry waste have been developed. The methods promoting not only utilization of these types of waste, but also further processing and use of slurries in production of construction materials are developed. The use of drilling sludge extracted from wells drilled on the Caspian shelf, including up to 80-90% of sandstones, clays and carbonate rocks, contributed to the formation of a solid cement-slurry matrix and utilization of drilling waste polluting the environment.

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