Technical and economic analysis of the proposed method of utilization of asphalt resin paraffin deposits (ARPD) in the composition of organomineral waterproofing material

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Abstract. Currently, for many construction industries promising becomes the creation of waterproofing materials on the basis of integrated management natural oily raw material, as well as improvement of traditional materials. Choice of material depends on the working conditions of a hydraulic installation, categories of reliability construction, its structures, the availability of local building materials, method of work and of technical and economic indices of construction. In this paper described economic and technical efficiency of using asphalt resinous paraffin deposits as a main composition of organomineral material for antifiltration screen. In this paper described technology of preparing oil waste sludge pit, where an antifiltration screen is used polymerorganic screen based on asphalt resin paraffin deposits (ARPD) and polymer material. Processing of oil waste and reducing their formation is a significant problem from the ecological point of view and requires new ecological and technological solutions. In this research paper analyzes the results of world practical experiments on the application of waste and presents technical solutions for the use of waste that are suitable for future application. The feature of this work is obtaining waterproofing materials based on asphalt – resin - paraffin deposits and polymer, moreover the improvement of its physicochemical properties. The results of experimental laboratory testing of the effects of aggressive components of waste on the physical and mechanical properties of the material made from polymerorganic and cement mixture are presented.

1. Introduction
Preparation of organomineral waterproofing material on the basis of ARPD will allow to achieve a number of environmental and economic advantages: reuse of oil wastes as secondary raw materials; enhancing the anti-–filtration properties of natural mineral components; Increasing the life of the anti-filtration protection as it increases the stability of the material to the aggressive environment [1].

The most accessible way to eliminate drilling wastes and operation of wells is their disposal. Practice the elimination of waste in specially designated areas, deep underground horizons. Burial in specially designated places provides for the use of special structures, abandoned quarries, etc. for this purpose. Such liquidation requires significant transportation costs, therefore it is considered economically impractical. Basically, they practice the collection and storage of industrial-technological semi-liquid drilling wastes directly in earth sludge pits on the site of the drilling site.

But pollutants contained in waste, due to their mobility and high penetrating ability, migrate to groundwater and pollute the environment [1]. Conducted full-scale studies using the proposed material as one of such layers of the protective screen laid on a protective layer of clay, proved the ecological
safety of the developed material for groundwater. However, in order to exclude the impact of the organomineral waterproofing material on the basis of ARPD also on the above-screen filtrate, we consider it advisable to arrange protective layers of clay above and below the layer of organomineral waterproofing material in the structure of the anti-filtration screen [2].

Preparation of organomineral waterproofing material on the basis of ARPD will allow to achieve a number of environmental and economic advantages: reuse of oil wastes as secondary raw materials; enhancing the anti-filtration properties of natural mineral components; Increasing the life of the anti-filtration protection as it increases the stability of the material to the aggressive environment.

2. Methods

Earlier we have made some experiments on waterproofing materials such as organic mineral and polymerorganic material, where sample characteristics had been published (Tanzharikov, et.al., 2018, Abilbek, et. al., 2017; Shomantayev, et. al., 2016). The economic efficiency of the use of ARPD in the composition of organomineral waterproofing material for the device of the anti-filtration screen is determined from the formula:

$$ E_a = C_b - C_a + D_{env,wast} $$  \hspace{1cm} (1)

Where $E_a$ - annual economic effect from replacement of reference designs on a design with use ACII;

$C_b$, $C_a$ - comparable cost price of the construction object before implementation ($C_b$) and after introduction ($C_a$), dollars;

$D_{env,wast}$ - is the amount of prevented environmental damage to the surrounding environment as a result of preventing 1 ton of I class waste from being placed at the expense of their use [3].

Calculations showed that the specific damage from the placement of 1 ton of oil waste is 8.48 dollars. At the device on the experimental section of the anti-filtration screen of organomineral waterproofing material, 506 tons of ARPD waste will be used, and the prevented environmental damage to the environment will be 4288.44 dollars.

The base version for comparing the effectiveness of the introduction of a new organomineral waterproofing material on the basis of ARPD during the device of the anti-filtration screen was a single-layer screen made of polyethylene film of the following construction [4]: etched and compacted base from a homogeneous soil; layer of sand 0.1 m thick; layer of high-density polyethylene film 1.0 mm thick; protective layer of fine-grained soil 0.5 m thick on the bottom and 0.8 m on slopes.

Economic estimation of the cost of the anti-filtration screen device for the experimental section of the Akshabulak field was carried out using the base-index method on the basis of estimated norms and rules for two options: 1) a screen using the developed organic-mineral waterproofing material based on ARPD; 2) a single-layer film screen.

The initial data for calculating the cost of the anti-filtration screen device in the experimental plot of Akshabulak for both variants is as follows: the area of the pilot section according to the general plan is 3750 m, the total screen area is 9200 m (including the area of the base of the test site is 3575 m, the area of the slopes is 5625 m).

The cost structure of the anti-filtration screen device with the use of the developed organomineral waterproofing material based on ARPD is given in Table 1, and a single-layer film-type anti-filtration screen in Table 2 [4].

Based on the results of calculations, the cost of constructing an anti-filtration screen in the experimental section of the Akshabulak field is: using an organomineral waterproofing material based on ARPD - 1676.40 $, using a high-pressure polyethylene film 1 mm thick - 4598.36$. The economic effect of the introduction of the developed material on the experimental site of the landfill, taking into account the prevented damage to the natural environment, is 3780.47 $ (by table 3).

Specific indicators of the cost of construction of the anti-filtration screen in the experimental section of the Akshabulak deposit are: for a screen with the use of an organomineral waterproofing material - 0.018 $ / m, for the film screen – 0.5$ / m. The specific value of the economic effect from
the introduction of the proposed material at the experimental site of the landfill is $0.41$ on 1 m (by table 3).

**Table 1.** The cost structure of the device of the anti-filtration screen with the use of organomineral waterproofing material on the basis of ARPD

| Name of works                                      | Unit of measurement | Quantity | Unit price 2018 | Total cost, $ |
|----------------------------------------------------|---------------------|----------|-----------------|---------------|
| Layout of notches (base)                           | 100 m²              | 37,5     | 5,14            | 0.45          | 12.09         |
| Sealing with out priming (base)                    | 100 m²              | 37,5     | 1,98            | 0.17          | 4.66          |
| Development of soil (loam)                         | 1000 m³             | 1,5      | 183,18          | 0.64          | 17.24         |
| Transportation of loam up to 1 km                  | 1t                  | 2700     | 0,32            | 2.01          | 54.21         |
| Repair and maintenance of roads during transportation | 1000 m³             | 1,5      | 5,3             | 0.019         | 0.50          |
| Work on the dump in the delivery of loam           | 1000 m³             | 1,5      | 15,01           | 0.053         | 1.41          |
| Development of loam by bulldozer                   | 1000 m³             | 1,5      | 27,21           | 0.40          | 10.84         |
| Soil compacting by roller                          | 100 m³              | 15       | 5,58            | 0.21          | 5.78          |
| Development of soil (clay)                         | 1000 m³             | 0,59     | 183,18          | 0.25          | 6.83          |
| Transportation of clay up to 1 km                  | 1t                  | 712,50   | 0,32            | 0.53          | 14.31         |
| Repair and maintenance of roads during transportation | 1000 m³             | 0,59     | 5,30            | 0.070         | 0.20          |
| Work on the dump at the delivery of clay           | 1000 m³             | 0,59     | 15,01           | 0.021         | 0.56          |
| The cost of sand with a haulage up to 30 km        | 235,78              | 2018     | 5,97            | 3.27          | 88.32         |
| Transportation of oil waste (ARPD) to 30 km        | t                   | 506,25   | 2,10            | 2.47          | 66.7          |
| Building hydratlime                                 | t                   | 281,25   | 28,90           | 18.89         | 509.98        |
| Preparation of hot soil                            | t                   | 2250     | 2,70            | 10.82         | 292.22        |
| Coating of hot mixes                               | 100 m³              | 281,25   | 8,94            | 5.84          | 160.08        |
| The cost of sand with a haulage                    | 1125                | 2018     | 5,97            | 15.61         | 421.40        |
| Development of soil (sand)                         | 1000 m³             | 1,13     | 21,98           | 0.26          | 7.05          |
| Soil compacting by roller                           | 100 m³              | 11,25    | 5,58            | 0.16          | 4.33          |
| TOTAL                                              |                     |          |                 |               | 62.09         |

**Table 2.** The cost structure of a single-layer film-type antifiltration screen

| Name of works                                      | Unit of measurement | Quantity | Unit price 2018 | Total cost,$ |
|----------------------------------------------------|---------------------|----------|-----------------|---------------|
| Layout of notches (base)                           | 100 m²              | 37,5     | 5,14            | 0.45          | 12.09         |
| Sealing with out priming (base)                    | 100 m²              | 37,5     | 1,98            | 0.17          | 4.66          |
| Development of soil (sand)                         | 1000 m³             | 9,2      | 21,98           | 0.47          | 135.84        |
| The cost of sand with a haulage                    | 920                 | 0,97     | 12.76           | 344.58        |
| Sealing of the soil with a roller (sand)           | 100 m³              | 92,0     | 5,58            | 1.19          | 32.19         |
| Laying of geomembrane from nonwoven synthetic material | 100 m²              | 92,0     | 8,94            | 1.91          | 51.57         |
Development of soil (loam) 1000 m³ 6,287 183,18 2.68 72.28
Compacting the soil with a roller (loam) 100 m³ 17,87 5,58 0.23 6.27
Cost of high-pressure film 1 m² 9200 7,037 157.42 4062.03
TOTAL: 170.31 4598.35

Table 3. The economic effect of replacing the film screen on the screen with a waterproofing layer of organomineral waterproofing material based on ARPD

| Material of the waterproofing layer of the screen | Calculation of the test plot of the area of 9200 m², $ | Calculation for 1 m² of the anti-filtration screen, $ |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| High-density polyethylene film 1 mm thick        | 4598,36                                          | 0                                               |
| Organomineral waterproofing material based on ASPO | 1676,38                                          | 3780,47                                         |

3. Results
The evaluation of the received technical and economic parameters of the construction of an anti-filtration screen with the use of an organomineral waterproofing material based on ARPD showed the expediency and cost-effectiveness of using the proposed material for waterproofing the grounds of solid waste landfills. The use of this material ensures reduction in 2.74 times in the cost of building an anti-filtration screen in comparison with the use of high-pressure polyethylene film for waterproofing, and it helps to prevent damage to the natural environment as a result of the non-admission to placement and use of ARPD (506 tons) in the amount of 858,49 $ or 0.093 $ / m of the screen [5].

The results of experimental studies in laboratory conditions established the emission of oil products - 0.00065% by weight from samples of organic mineral waterproofing material based on ARPD. On the basis of the obtained results, the device of the anti-filtration screen is theoretically justified on the basis of the "material in cage" principle by insulating the waterproofing material with constructive clay layers, to prevent the migration of oil products to underground horizons and the over-screened filtrate [6-8].

The results of full-scale studies confirmed the high water resistance of the anti-filtration screen, consisting of organomineral waterproofing material laid on top of the clay layer. The coefficient of filtration of such a screen, obtained in full-scale conditions (1 + 4.14) * 10⁻⁹ m / s is an order of magnitude higher than the same coefficient obtained in laboratory conditions (0.95 - 1.5) * 10⁻¹⁰ m / s. At the same time, the screen filtration coefficient corresponds to the normative value of the coefficient established both for the waterproofing materials of the bases of the solid domestic waste landfills in Kazakhstan (1*10⁻⁷ m / s) and for the industrial waste landfills (1*10⁻⁹ m / s) [9-14].

4. Discussion
Full-scale studies have proved the ecological safety of the anti-filtration screen with the use of an organomineral material based on ARPD. The emission of oil products from such a screen in the leachate leaked through the screen, both during the pouring of water and the mineralized filtrate of the landfill did not exceed the MPC (0.27-0.33 MPC).
The technical specifications for the waterproofing mix (TU 5775-105-02069065-2000), the design, technology and organization of the construction of the anti-filtration screen of waste disposal landfills with the use of the material studied are developed. The proposed technical solutions were implemented during the development of a feasibility study for the development of the experimental site of the Akshabulak field. 

The completed project was implemented by «Abu-Ser» LLP on a 0.375 ha plot located near the Akshabulak field. Its implementation allowed to ensure the regulatory requirements for anti-filtration properties of the grounds of the polygons.

The ecological and economic efficiency of ARPD utilization in the composition of organomineral waterproofing material is grounded. The use of the proposed material for the device of the anti-filtration screen provides in 2.75 times reduction in the cost of building a screen in comparison with a screen made of high-pressure polyethylene film; allows to prevent damage to the natural environment as a result of non-admission to placement and use of ARPD (506 tons) in the amount of 858,49$. The economic effect from the introduction of the developed material at the experimental site of the solid domestic waste landfill (0.375 ha) amounted to 3780,47$.

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