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Research paper

Watertight Soil-Cement Dump of Oil and Gas Industry Waste

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Abstract

It is established that the most accessible way of isolation of toxic wastes formed during drilling, development, exploitation and treatment of oil and gas wells products is to dispose them directly in the earth's slime dumps on the territory of the drilling site or beyond. The dump's pit must have a watertight protective diaphragm, which is durable and resistant to the aggressive effects of toxic waste drilling and exploitation of oil and gas wells. The chemical composition of the borehole mud is determined. The results of experimental laboratory researches of borehole mud aggressive components influence on the physical and mechanical watertight diaphragm characteristics are given. The geotechnical parameters of soil-cement were analyzed with the aim of its application for the arrangement of toxic waste watertight dump's diaphragm.

Keywords: *dump; to chemical attack, resistance, soil-cement toxic waste, watertight diaphragm,.*

1. Introduction

Drilling deep wells, which is an integral part of exploration and extraction of oil and gas, creates a significant man-made load on the geological environment. As a result of well drilling, dangerous geodynamic processes develop. A large number of toxic chemical elements and compounds move to the hydrosphere and lithosphere surface areas [1, 2].

One of the priorities of drilling operations is the maximum possible conservation of the environment natural state [1 – 5].

It is known that drilling rigs belong to objects of high ecological danger. This is due to formation of significant volumes of waste, such as spent drilling mud, drill cuttings and drilling wastewater, formation fluids and active chemicals. While drilling wells, chemical reagents and substances of III and IV danger classes for the drilling fluids preparation are used [6].

When exploiting wells, various acids concentrated solutions are used for the intensification of hydrocarbons extraction [6, 7]. At the production stages, oil or condensate emissions occur. The ingress of these processes in reservoirs, soils, groundwater in large areas is environmentally dangerous.

Depending on the composition, chemical properties and features of interaction with oil fractions, chemical elements are used in the drilling, extraction, preparation and transportation of oil and gas. According to their functional purposes they are divided into groups [5, 7]:

- chemical compounds for drilling muds preparation;
- substances for bottomhole formation zone treatment;
- chemicals that contribute to oil and gas deposits;
- reagents that are added to fight against hydrated, asphalt spasmolytic and paraffin deposition and with corrosion.

To prevent soil from entering, surface and underground waters of toxic waste drilling and exploitation of oil and gas wells, the obligatory precautionary measure is the land dumps arrangenebt for their collection.

Making a reliable watertight diaphragm of dumps is a vital task of the present.

Modern norms recommend earth dumps to be arranged with watertight screens of impermeable coating: a layer of sealed clay, polyethylene membrane, concrete or asphalt screens, etc.

Dimensions of dump are determined by the project and should correspond to the amount of waste drilling and operation of wells. Terms of dumps design and their construction depend on the engineering and geological conditions of mass oil and gas production area and characteristics of the soils in this area [1 – 7].

The experience of exploiting the toxic waste dump shows that the arrangement of membrane, concrete and asphalt screens does not justify its purpose. While laying and further exploitation of the polyethylene membrane the fluid flows on the joints.

In addition, in the process of its laying and further exploitation discontinuities of the membrane often occur and the toxic waste flow into the environment. The same can be said about concrete and asphalt screens [4].

Due to imperfection of waste dumps plane watertight diaphragm, it is proposed to arrange dry vertical diaphragms, which are made according to the "wall in the soil" principle of impenetrable chemically resistant materials. Such screens should be deepened in impenetrable strata of soil to create a complete waterproofing of the dump [4].

As for the diaphragm technology and its material, it is advisable to use soil-cement, which is produced by the mixing method [8 –17].

Soil-ement is a building material that is a mixture of clay or sandy soil and cement in the ratio of dry soil 80 – 90%, cement 10 - 20% with water-cement ratio W / C = 0,6 – 1,2.

For soil-cement production they use soil from the earth's surface at the site of diaphragm construction [8 – 10, 14 – 17].

The cement has sufficient strength. It is a waterproof material, for water resistance W = 7 – 9, when it is made from fine and dust

sands and W = 10 – 12, when it is made from sand clay and loams [15 – 17].
Increasing the waterproofness of watertight diaphragm, underground structures of buildings, reservoirs can also be achieved by adding a hydrophobic additive "Silpan-S". Experimentally, the grade of concrete with W10 water resistance has been reached, which can not be obtained only at the expense of concrete staining [18].
Diaphragm material, including ground cement, should be checked for chemical resistance. To do this, it is necessary to analyze the chemical composition of oil and gas production waste to determine the most aggressive of them for the diaphragm material, as well as to study the soil-cement to its chemical resistance.
In accordance with the solved problem, the purpose of the work is to develop a new principle for the design and placement of toxic waste from oil and gas production with effective design of watertight diaphragm.

2. Main Body

Arrangement of dunps for the storage of oil and gas production toxic waste requires preliminary engineering and geological surveys to determine the favorable conditions for their long-term exploitation.
The main factor that determines the suitability of the site for landing is the presence of a layer of soil within 10 meters of the earth's surface that has the properties of the watertight stratum; the filtration coefficient of such strata is $k_f \leq 0{,}001$ m/day.
The presence of such engineering-geological conditions permits the construction of a dump in the form of a foundation pit in the unobstructed dimensions, which is surrounded by a rigid monolithic watertight screen immersed in a watertight layer of soil. Such a construction of a dump, subject to a qualitative watertight diaphragm, can protect the environment from the action of toxic waste oil and gas production lasting from decades to centuries.
The main issue to be investigated is the impact of toxic waste from oil and gas production on the soil-cement chemical resistance.
The design of the watertight dump of toxic waste should be characterized not only by the mechanical strength and resistance under the influence of the workload, but also due to the durability under the destructive impact of various external chemical and physical factors [12].
Let's consider this problem on the example of oil and gas wells waste drilling.
The chemical components of oil and gas wells drilling and exploitation waste, contacting in soil bunkers with soil-cement, cause II and III types of soil-cement corrosion [19, 20].
The II type of corrosion refers to processes that develop under the action of water, which contains substances entering a chemical reaction with a cement stone. The products formed during this reaction are carried out with water or stand out on the spot in the form of amorphous masses that do not possess astringency.
For II type, for example, corrosion processes associated with the action of concrete on various acids and salts can be attributed.
The III type of corrosion refers to the combined processes of corrosion caused by exchange reactions with the components of the cement stone. The products of such reactions crystallize in pores and capillaries.
They cause cement stone destruction. The same type includes corrosion processes due to deposition in salts stone pores, which are released from solutions that are evaporated and saturated with soil-cement.
As a rule, many aggressive factors act simultaneously on the cement constructions, but the main one is the process causing corrosion of the II type.
Consequently, the analysis showed that chemicals that are included in the formulation of various drilling fluids preparation are the most aggressive to the cement stone. We use them to determine the chemical corrosion resistance of soil-cement to the individual action of each of the three aggressive chemical reagents with maximum concentration in the drill waste:
- 2,8% caustic soda solution ($NaOH$);
- 4,0% soda ash solution (Na_2CO_3);
- 15,0% potassium chloride solution (KCI).

The listed chemicals are classified into III and IV eco-logical danger classes and are probably the most destructive (aggressive) to the soil-cement.
The corrosion resistance of building materials is called their ability to withstand the destruction processes occurring in materials under the influence of external aggressive factors [19, 20].
The resistance of the soil-cement to the impact of the aggressive environment is estimated by the chemical resistance coefficient K_s, which is equal to the ratio of the strength limit at the compression of samples exposed to such a medium R_a to the strength limit at the control samples stored in water R_w.

$$K_s = R_a / R_w. \quad (1)$$

By the value of K_s the following is distinguished: materials of high resistance ($K_s > 0{,}8$); stable ($K_s = 0{,}5 – 0{,}8$); relatively stable ($K_s = 0{,}3 – 0{,}5$); unstable ($Ks < 0{,}3$).
To check soil-cement for chemical resistance, we conducted laboratory tests for which samples of cylindrical shape with dimensions h = 15,0 cm, d = 15,0 cm were made, which included soil (loam) and portland cement of the grade M400 in quantity of 20% of dry soil and water weight.
The second day after the samples formation, they were extracted from the molds and stored for testing in water for 28 days (time for strength generation).
The samples were divided into four groups of 30 specimens in each and placed in a container with chemically prepared solutions of the most aggressive components of the drilling mud, as well as for comparison with the water tank, for further laboratory tests of soil-cement for corrosion resistance:
- I group – water (H2O);
- II group – 2,8% caustic soda solution ($NaOH$);
- III group – 4,0% soda ash solution (Na_2CO_3);
- IV group – 15,0% potassium chloride solution (KCl).

Tests of soil-cement samples on strength were carried out in accordance with [18] as for concrete.
Test conditions: temperature 18 – 22 ºC, atmospheric pressure.
These tests were performed using a test machine – hydraulic press PH-100 (Fig. 1).

Fig. 1: Tests of soil-cement samples on uniaxial compression on PH-100 hydraulic press

Determination of strength consists in measuring the minimum forces that destroy specially made control samples with their static loading. The maximum effort, reach-bent during the test, taken for a destructive loading, and entered in the test journal.
According to the tests, the compressive strength R was determined (Table 1).

Table 1: The averaged findings of physical and mechanical characteristics of soil-cement samples (cylinders h = 15 cm, d = 15 cm) with different chemical solutions and water conditioning period

Medium	Holding time t, days	Humidity W, % (coefficient of variation υ)	Soils zero-air dry unit weight ρd, t/m3 (coefficient of variation υ)	Compressive strength R, MPa (coefficient of variation υ)	Coefficient of chemical resistance
H2O	30	37 (0,05)	1,33 (0,03)	5,52 (0,06)	
NaOH		35 (0,07)	1,37 (0,05)	5,37 (0,08)	0,97
Na2CO3		36 (0,06)	1,38 (0,04)	5,21 (0,07)	0,94
KCl		37 (0,08)	1,56 (0,03)	4,96 (0,08)	0,9
H2O	90	35 (0,04)	1,41 (0,04)	6,43 (0,08)	
NaOH		34 (0,08)	1,44 (0,02)	6,19 (0,07)	0,96
Na2CO3		32 (0,09	1,46 (0,04)	5,95 (0,09)	0,93
KCl		30 (0,09)	1,37 (0,05)	5,77 (0,08)	0,9
H2O	180	26 (0,07)	1,57 (0,05)	6,89 (0,09)	
NaOH		29 (0,09)	1,36 (0,07)	6,61 (0,07)	0,96
Na2CO3		27 (0,05)	1,43 (0,06)	6,13 (0,08)	0,89
KCl		26 (0,07)	1,41 (0,04)	5,82 (0,06)	0,85
H2O	270	25 (0,07)	1,58 (0,07)	7,74 (0,06)	
NaOH		28 (0,06)	1,49 (0,06)	7,22 (0,09)	0,93
Na2CO3		26 (0,07)	1,52 (0,07)	6,85 (0,08)	0,89
KCl		28 (0,05)	1,44 (0,08)	6,43 (0,07)	0,83
H2O	360	23 (0,06)	1,66 (0,06)	7,95 (0,09)	
NaOH		24 (0,07)	1,64 (0,05)	7,44 (0,07)	0,93
Na2CO3		23 (0,05)	1,53 (0,07)	6,97 (0,08)	0,88
KCl		22 (0,04)	1,60 (0,08)	6,59 (0,09)	0,83

Before testing, the density of soil-cement ρ, humidity W, zero-air dry unit weight ρ_d was calculated. Each determination of soil-cement characteristics occurred in 6-fold repetition.
The average compressive strength of soil-cement samples of a certain term and of the aging medium is obtained. For each characteristic, the coefficient of variation υ was determined.
All test data are summarized in Table 1. For statistical analysis of the of soil-cement samples strength values, data were also taken from Table 1.
Separately, for each medium a point diagram with a logarithmic trend line was constructed (Fig. 2).
According to these data, the least-squares method yields the equation and the determination value for the determination coefficient R^2 separately for each medium of exposure to samples of soil-cement. The logrhythm trend line is used to approximate data using the least-squares method according to the equation

$$y(x) = a\cdot\ln(x) + b. \quad (2)$$

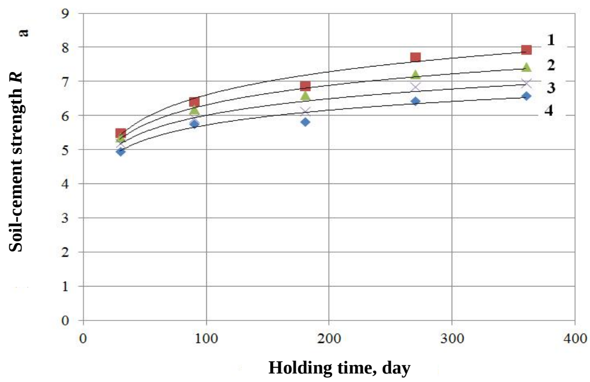

Fig. 2: Logarithmic trend line for the dependence of the soil-cement strength *R* on the holding time *t*: 1 – water; 2 – caustic soda solution NaOH; 3 – soda ash solution Na_2CO_3; 4 – potassium chloride solution KCl

Equation of the logarithmic trend line for the medium:
1) water (H_2O)

$$y = 0,9807\cdot\lg(x) + 2,0851; \quad (3)$$

2) caustic soda solution (NaOH)

$$y = 0,8287\cdot\lg(x) + 2,4923; \quad (4)$$

3) soda ash solution (Na_2CO_3)

$$y = 0,7023\cdot\lg(x) + 2,7699; \quad (5)$$

4) potassium chloride solution (KCl)

$$y = 0,6294\cdot\lg(x) + 2,8201. \quad (6)$$

Determination coefficient R^2 characterizes approximation accuracy. Proceeding from its value, it is accepted in statistical practice to apply the following gradation of trend matching to a dynamic series: 0 – lack of communication; to 0,3 – weak; from 0,3 to 0,6 – average; from 0,7 to 0,9 – high; from 0,9 to 1,0 – the selected trend fully corresponds to the dynamic range.
Determination coefficient for the medium was:
1) water (H_2O)– R^2 = 0,966;
2) caustic soda solution (NaOH) – R^2 = 0,981;
3) soda ash solution (Na_2CO_3) – R^2 = 0,946;
4) potassium chloride solution (KCl) – R^2 = 0,941.

Consequently, the resulting determination coefficients are within the range of 0,9 to 1,0 degrees of trend matching dynamical series. This means that the selected trend is fully consistent with the dynamic range. To verify the equality of the two samples dispersion, Fisher's criterion (F-test), separately for each of the 4 medium, was also determined.
Estimated value of F-test for the medium:
1) water (H_2O) – F_{calc} = 28,59;
2) caustic soda solution (NaOH) – F_{calc}= 52,48;
3) soda ash solution (Na_2CO_3) – F_{calc}= 23,45;
4) potassium chloride solution (KCl) – F_{calc}= 21,19.

The value of the critical value of F_{crit} was determined by the statistical tables for the significance level α = 0,05. It is equal to 19,30. Since for each of the medium $F_{calc} > F_{crit}$, the resulting regression equations are taken as statistically significant, the hypothesis about the model adequacy is confirmed.
According to tabl. 1 the dependence graph of soil-cement samples chemical resistance coefficient on the holding time and medium was constructed (Fig. 3).

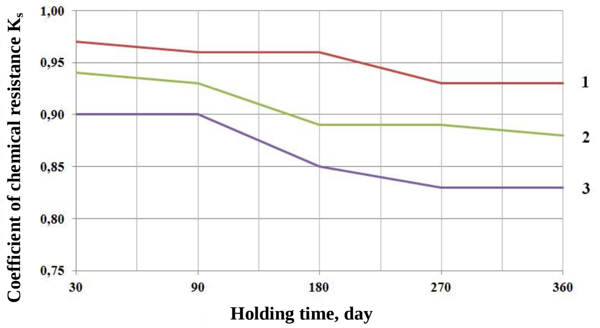

Fig. 3: Graph of chemical resistance coefficient K_s dependence on the holding time and medium: 1 – caustic soda solution NaOH; water; 2 – soda ash solution Na_2CO_3; 3 – potassium chloride solution KCl

The graphs show a slow gradual decrease in the soil-cement chemical resistance coefficient depending on the holding time in aggressive medium. In this case, the chemical resistance coefficients K_s remain within the limits that characterize the soil-cement as being chemically highly stable.
According to the graphs (Fig. 3), a slow decrease in the chemical resistance of soil-cement can be observed depending on the holding time in aggressive medium.
At the same time, the chemical resistance coefficients K_s remain within the limits that characterize the soil-cement as chemically highly stable.
It is known that the soil-cement, which is made by the mixing technology, has a porosity that is close to the porosity of the natural soil. This fact gave rise to the false idea that the permeability of the soil-cement is close to the natural soil.
Therefore, vertical soi-cement elements with diameters of 200 mm and 2,5 m in length were used to determine soil water-tightness characteristics on the experimental soil from loam.
The amount of portland cement M400 is 20% of dry soil weight, the water-cement ratio W/C = 1. After the production, the samples were stored for 28 days under humid conditions.
Waterproofness of concrete was determined in laboratory conditions using the "wet spot" method. To do this, we used the device shown in Fig. 4
Waterproofness is estimated by the maximum pressure of water, under which its seep through the sample is not yet observed.
Before the test, the samples were kept in the room of laboratorium during the day. After installation of the device samples, they were pressurized with water. Grade of concrete on waterproofness accepted for tabl. 2.

Fig. 4: The device for testing the samples by the method of "wet spot"

Table 2: Concrete grade on watertightness for "wet spot"

Watertightness of a series of samples, MPa	0,2	0,4	0,6	0,8	1,0	1,2
Concrete grade on watertightness *W*	2	4	6	8	10	12

At the same time the watertightness of the soil-cement samples was determined by the express method for assessing the air permeability of the VV-2 type "Agama" (Fig. 5).

This device is used to accelerate the watertightness determination. The method is based on the existence of an experimental dependence between the air permeability of the surface layers of soil-cement and its watertightness.

Fig. 5: The device BB-2 for accelerated test of watertightness

While using the device as a parameter characterizing air permeability, the time value is used for the pressure reduction by a certain amount. Range the device indicators of BB-2 vacuum meter is 0 ... 1 kgf / sm2; weight of the device – 4 kg.
According to the standards, the air permeability of concrete is determined according to the results of a series of 6 cube samples tests with a 150 mm rib or cylinder diameter of 150 mm and a height of at least 100 mm.
Tests are carried out at an air temperature from +1 to + 40 °C. Two days prior to testing, the concrete surface should not be exposed to water or other liquid.
The surfaces on which the test will be carried out must be cleaned from the surface cement stone film. In the contact area of the flange, the camera with the concrete surface should not have airpocket with a depth of more than 1 mm and a diameter of more than 6 mm, as well as projections greater than 1 mm and visible cracks.
Tests are conducted in the following sequence:
1. Insert the camera in the selected and prepared area of the sample and press the device to the surface with two hands, creating the required compression pressure σ = 0,05 MPa.
2. A vacuum pump in the chamber creates a dilution to a value of σ = 0,075 – 0,08 MPa.
3. Remove the end of the hose, install a plug on the fitting and observe the pressure drop pressure gauge to the value σ_{01} = -0,060 MPa. This pressure is considered as the initial dilution pressure. From this moment, the time for which the pressure in the chamber falls to the final dilution σ_{02} = - 0,054 MPa is measured.
The resulting values of t_i for the samples under study are recorded in their order of magnitude and calculate the average arithmetic mean of the time of two average samples (third and fourth) as a parameter characterizing the air permeability in a series of samples.
Watertightness of concrete W is determined by the table "time - a grade of concrete for watertightness" (Table 3).

Table 3: Concrete grade for watertightness for the device BB-2

Time t_i	41 – 59	60 – 87	88 – 126	127 – 183	184 – 261	262 – 387	388 – 561	562 – 814	815 – 1181	1182 – 1734
Grade W	2	4	6	8	10	12	14	16	18	20

In order to check the correctness of the device and confirm the appropriateness of its use for samples of soil-cement, a watertightness grade was first defined for the reinforced concrete beams of the factory production, which has a W2 grade.
According to the results of six tests, the pressure drop time in the chamber for the 3rd and 4th test was as follows: 44 and 52 s respectively.

The arithmetic mean of the time was 48 s, which is according to table 3 corresponds to the concrete brand for the watertightness of W2. Consequently, this device can be used to determine the water-permeability of the samples.
To determine the water resistance, an element of soil-cement, 200 mm in diameter, selected on the test site, was cut into cylinders with a height of 150 mm.
Then the surface was purified, taking into account all of the above requirements, and 6 tests were performed (Fig. 6), the results of which are given in table. 4.

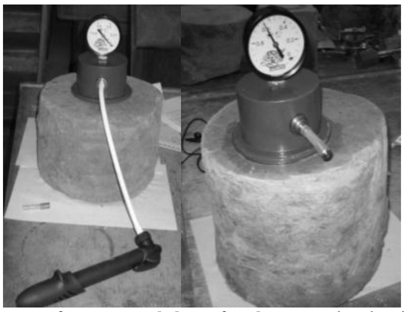

Fig. 6: Investigation of air permeability of soil cement-by the device BB-2

Table 4: The time value and grade of soil-cement samples

№ sample	Time t_i, s	Grade *W*
1	305,27	12
2	320,58	12
3	445,00	14
4	480,54	14
5	520,30	14
6	784,98	16

Taking into account the data of the table 4, the arithmetic mean value of the pressure drop time in the chamber for the 3rd and 4th tests is t = 463 s, which corresponds to the watertightness grade for the concrete W14.
If the mark on water resistance is determined by the average-rhythmic value of the time pressure drop in the chamber of all the conducted studies (in our case, 6), then according to the given table 4 t_{aver} = 476 s, which corresponds to the W14 watertightness grade.
The coefficient of variation, determined as a result of static data processing by the least squares method, for this test was V = 0,11. The value of the coefficient of variation corresponds to the general representations of the soil. This suggests that the soil-cement has a rather high water resistance.
The following should be note: to make concrete grade for water resistance W14, not only add special hydrophobic additives have to be added, but technology of this concrete additive have to be strictly keptp. All these measures considerably increase the cost of such concrete, which by itself is more expensive than soil-cement.
Since soil-cement is also considered as a strengthened soil, the water absorption coefficient ought to be determined to assess its water resistance. According to the standard and to the softening factor, the soils are divided into non-softening ($K_{sof} \geq 0,75$) and softening ($K_{sof} < 0,75$).
Subsequently, cube sizes of 7x7x7 cm were made from the explored samples of soil-cement with a diameter of 200 mm and a height of 150 mm. The cubes were measured and divided into two series of 6 pieces: samples of the first series were stored for 28 days in water; samples of the 2nd series were stored for 28 days in air-dry conditions.
After the accepted storage period under the given conditions, the samples were tested for uniaxial compression. According to the results of the tests, for each sample, the strength of the soil-cement was determined on the uniaxial compression R – the ratio of the load at which the destruction of the sample occurs in the area of the original cross-section.
Test data is given in Table. 5.

Table 5: The strength limit for the uniaxial compression of soil-cement samples R, MPa

№ sample	R_a, MPa (air-dry)	R_w, MPa (water-filled)
1	1,38	1,55
2	1,50	1,48
3	1,45	1,45
4	1,31	1,59
5	1,30	1,74
6	1,37	1,46
Average	**1,39**	**1,54**

Also, for the obtained values of soil-cement strength, statistical data processing using the least squares method was performed. The coefficient of variation for samples stored in air-dry conditions was V=0,057; for samples stored in water – V = 0,092.
The obtained data testify to homogeneity of the soil-cement as a material and high accuracy of the experiment.
According to table 5, the softening factor for samples of soil-cement, which is made by mixing technology from loessial soil and cement with its content of 20% by weight of the dry soil, is K_{sof} = 1,54 / 1,39 = 1,11> 0,75.
These tests of soil-cement, as a reinforced soil, on softening have shown that the soil-cement aside from not dissolving in water, also increases its strength. This fact is confirmed by the data of other researchers [17].
If you compare the soil-cement with concrete, then when storing concrete in water, there is also a more intense increase in strength. To a large extent, this is due to the fact that in concrete does not form pores from the evaporation of water, in which the pressure of water is directed from the outside of the concrete.
At water storage pressure is directed from the external environment into concrete [17].
The high grade of soil-cement for water resistance and the value of the softness factor, which is greater than unity, is supported by the fact that the loessial soil with cement assumse to water resistance. Such high water resistance is due to its mineralogical composition.
The experimental loessial soil belongs to soils, which are composed of minerals of the kaolinite group, having a relatively small dispersion and exchange ability. Minerals of the kaolinite group have a fixed crystal lattice, exchange reactions with products of hydrolysis of cement pass on the surface of soil particles and end quickly enough – until the beginning of solidification of cement.
Also, the exchange cations of the soil absorption complex make a significant impact. It is carbonate varieties of soils, such as loessial soil, reinforced with cement, have high strength and water resistance. This is explained by the fact that the absorption complex of such soils is saturated with calcium ions, which contributes to the coagulation of fine particles.
As a result, the specific surface of the soil sharply decreases and a more solid microstructure is formed.
The conditions of hardening of cement in such soils are most favorable, since the diffusion layer of the micelle in advance, before the introduction of cement, is already largely saturated with calcium cations. Hydrogen index of carbonate soils is usually more than 8, which indicates the presence of alkaline medium, which is favorable for solidification of cement.
However, the high grade of soil-cement obtained for water-tightness characterizes only high water resistance of this material. In calculations, such an indicator of permeability as a filtration coefficient is used.
According to the norms of each received concrete grade for waterproofness corresponds to a certain value of the filtration coefficient. The maximum grade of concrete for water resistance, for which the filtration coefficient is determined, is W12, - $K_f = 6 \cdot 10^{-11}$ cm/sec or less.
For experimental loessial soil, high porosity, filtration coefficient is $K_f = 0,58 \cdot 10^{-5} – 1,16 \cdot 10^{-4}$ cm/sec (0,05 – 0,1 m/day). That is, when reiforsing loessial soil of cement in the amount of 20% of

the weight of dry soil, the coefficient of soil filtration decreases by $10^6 – 10^7$ times.

Consequently, experimental studies have shown that the soil-cement is a watertight and chemically resistant material in relation to drilling wells waste and can be used as material for watertight diaphragm of toxic waste dumps.

Constructive features of toxic waste dumps of oil and gas production we will consider on example of goudron dump placement in the engineering-geological conditions of the central region of Ukraine. In the geological structure of the research area, the motley complex of upper chalk, neogene and quaternary deposits are involved.

Almost everywhere from the surface lie different in genesis and lithologic composition of the Pleistocene accumulation. The most widespread among them is Eolian-deluvial foraminifed sand clays and loams.

According to the geological structure, three aquatic systems are identified: Quaternary, Neogene and Upper Cretaceous. Almost all of them are used for water supply of adjacent settlements. An important feature of the waters of this horizon is sufficiently close to the surface, easy availability for use, adequate water quality and, at the same time, a high vulnerability to anthropogenic pollution due to absolute natural insecurity.

According to the results of engineering-geological surveys, it was discovered that in the geological structure of the area involved Quaternary, Neogene and Upper Cretaceous deposits.

Isolation of soil and groundwater from the content of toxic waste from the goudron collection is carried out by the construction of a vertical watertight diaphragm in the form of a "wall in the soil" of soil-cement elements made by mixing technology without removing the soil.

The "Wall" is located along the perimeter of the collection at a distance from the coastline of 3 m and deepens into a water-bearing layer of soil at a depth of at least 1 m.

The scheme of the dump of acid coudron with the location of the watertight diaphragm on the territory of solid household waste is shown in Figure 7.

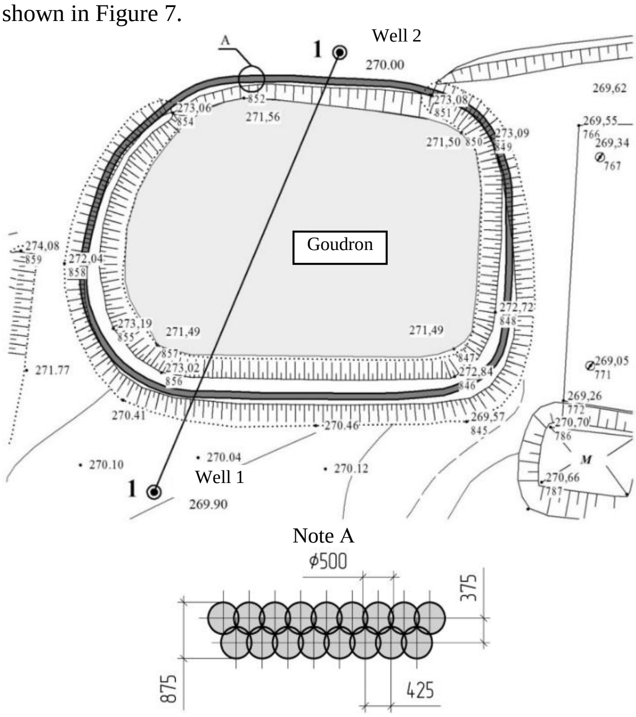

Fig. 7: Goudron dump scheme

Soil plating is indicated on the engineering-geological section (Fig. 8). The level of groundwater is located at a depth of 6,5 m.

The gudronic collection has the following parameters: length – 25 m; width – 20 m; depth – 2,5 m; area – 0,05 hectares; volume of liquid tar – 150 m^3; the volume of acid water – 900 m^3. The specification of the soil cement elements is given in Table. 6

Table 6: Specification of soil-cement elements

Position	Denotation	Nominatation	Amount	Total length meters
A	SSE	SSE-0,5-11,5	540	6210

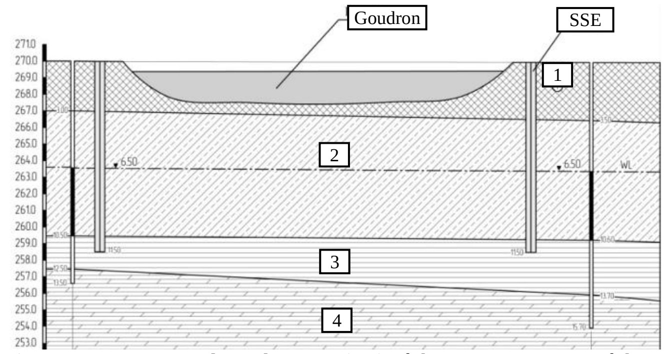

Fig. 8: Engineering-geological section (1-1) of the construction site of the anti-filtration curtain of the fuel oil collection: Strata 1 – fill-up soil; Strara 2 – sand clay with layers of loam and sand; Strata 3 – bass (waterproof layer); Strata 4 – a marl of reduced strength

The project developed watertight diaphragm of the type "wall in the soil" of soil-cement elements (SSE) with a diameter of 500 mm in the amount of 540, placed with a step of 425 mm in two rows, and a length of 11,5 m, which extend 1 m in the water-proof layer of soil (Strata3 – bass).

The hydrogeological conditions are favorable for the normal strength of the forage due to the soil-cement because the soil-cement elements are practically the whole length below the groundwater level.

Based on finite elements evaluation in the Plaxis 3D software package (soil model – Hardening Soil Model in the form of an elastic-plastic transition capable of compaction; a model of soil-cement – linear Linear Elastic) [21] of the stress-strain state of the system "soil-cement – watertight diaphragm of dump of toxic substances – soil foundation" for various engineering-geological conditions it was established that for the two-row placement of vertical SSE, the stability factor at the stage of excavation was 2,5, which is more than the normative value (1.2).

At the stage of filling the pit with drilling mud there is an additional pressure on the bottom and the wall, which reduces the tensile stresses in the structures of the fence. For the described conservations of dumps the stock is 2 - 2,5 times.

The horizontal displacements of the protective anti-filtering wall from vertical SSE vary in the range of 2 – 5 mm depending on the soil conditions. Burying the bottom of the excavation dump at the stage of excavation is from 10 to 20 mm.

Thus, the above solution is nature and resource-saving. It substantiates the necessity and expediency of the construction of a soil-cement watertight diaphragm to isolate toxic residue holdings.

3. Conclusions

The wastes from the oil and gas industry are very toxic to the environment. Most of them are buried in underground dumps, but the construction of these dumps does not provide on-site conditions of operation due to insufficient sealing. The ecological expediency of these dumps installation in certain engineering-geological conditions has been proved, when soils with properties of water tides lie on the depths of 10 – 12 m.

Under these conditions, the landfill is protected by a continuous impermeable watertight diaphragm that reliably extends into the water trough. As a screen, a design was made of slabs of soil-cement elements, which are made by the mixing method.

It is proved that the soil-cement is waterproof and chemically resistant to toxic substances contained in the landfill. The chemical resistance of the soil-cement is verified for the waste of the well drilling process.

It is necessary to check the chemical resistance of soil-cement if you are designing dumps for other toxic substances.

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