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PROPERTIES OF PROCESSED DRILLING WASTES FROM THE FACTORY OF ECOLOGICAL LABOURS IN TARNOGRÓD****

1. INTRODUCTION

Processed drilling fluids belong to wastes, that demand an appropriate initial treatment before major reprocessing because of their chemical composition and texture. There are numerous methods of managing wastes of this kind [3, 12–14]. One of the methods stands on storing processed drilling fluids on specially adapted landfills.

In the Factory of Ecological Labors only water-based fluids (so called Water Based Mud) are reprocessed, after being used in the national drilling industry in order to drill clay-shale layers as well as reaching oil and gas lodes. Those fluids are classified in the wastes index as: drilling fluids and other drilling waste, and signed with a code 01 05 [2].

The solid part of processed no-clay fluids, that generally consists of calcium carbonate and clay minerals, creates colloidal gel solution and stable water dispersions.

Regarding the tendency of processed drilling fluids to be both sludge and colloid–suspension, pre-process technology is required, which tasks is to recreate fluids consistence. For this purpose, it is necessary to conduct coagulation of processed fluids thanks to which fluid and solid phases can be divided. Having carried out initial coagulation, drilling fluids are filtrated in order to separate the postcoagulated phase from part of the fluid waste. This process is run in a chamber filter press.

Wastes achieved during fluid phase filtration (i.e. filter cake) beige coloured are mineral grounds and they are highly cohesive and wet in their characteristics.

Filtrated and aggregated drilling fluid wastes (filter cakes) are tested in the laboratory towards selected physical and mechanical features.

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The results of the research were the basis for creating methods of modifying processed drilling fluids' characteristics, that led to provide save landfilling of the waste.

2. PHYSICAL FEATURES AND SOIL CONDITION

Granulometric analysis

A granulometric composition of tested waste/filter cakes was determined with a grain sieve analysis [4, 5, 8, 15]. The grain-size distribution curve is to be seen in Figure 1 [1], while Figure 2 is shows the chart of the granulometry location.

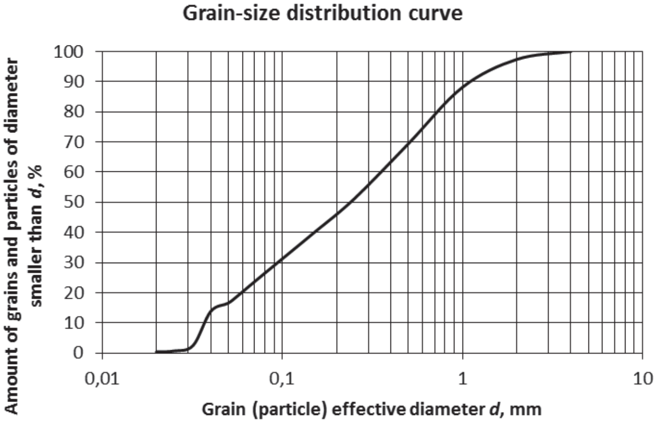

Fig. 1. Waste/filter cake's grain-size distribution curve [1]

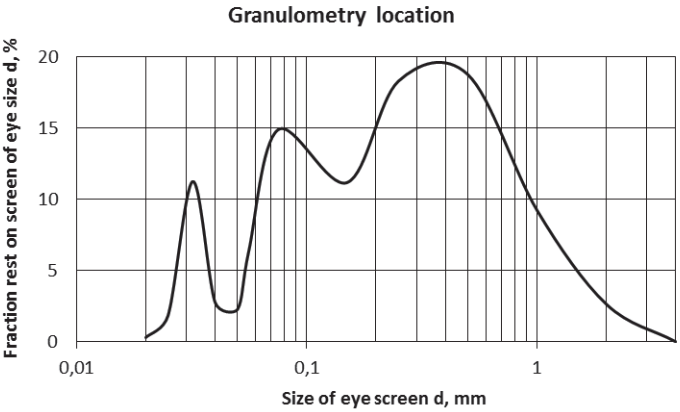

Fig. 2. Waste/filter cake's granulometry location

An analysis of the charts (Fig. 1, 2) shows that tested waste is a multi-fraction ground ($C_u > 6$, $C_c < 1$) [9] and may be classified as dusty sand siSa in terms of content and size of particular fractions [9].

Physical features

Laboratory testing enabled the determination of the following physical features of waste/filter cake: bulk density of soil ρ, water (moisture) content W, consistency boundaries (liquid limit W_L, plastic limit W_p), plasticity index I_p, liquidity index I_L, consistency index I_c [4, 5, 7, 15]. Tests results are collected in Table 1.

Table 1

Physical features of waste/filter cake

Quantity name, unit	Value
Water (moisture) content W [%]	63.85
Bulk density of soil ρ [kg/m^3]	1414
Liquid limit W_L [%]	75.57
Plastic limit W_P [%]	40.06
Plasticity index I_p [%]	35.51
Liquidity index I_L	0.67
Consistency index I_c	0.33

Test results indicated high content of moisture in the waste/filter cake, what results in its law bulk density (Tab. 1).

An analysis of consistency boundaries as well as consistency index and plastic limit values points to very high cohesion, plastic consistency and a very plastic state of waste/filter cake [4, 5, 9, 15].

Swelling

Ground swelling test was lead in the laboratory with the use of device M4600 HPHT Linear Swell Meter, produced by Grace Instrument. Previously, a sample of the ground was dried to the solid part at a temperature of (110 ± 5)°C. A chart showing waste/filter cake swelling is in Figure 3 [1]. The values of the parameters characterizing the swelling process are in Table 2.

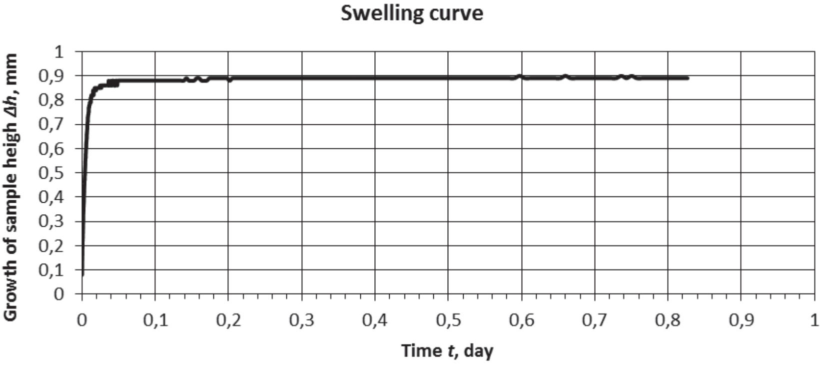

Fig. 3. Waste/filter cake swelling chart [1]

Table 2
Values of parameters characterizing waste/filter cake swelling

Quantity name, unit	Value
Swelling index E_p [%]	8.1
Swelling level	high
Swelling moisture W_{Ep} [%]	28.70

Lead tests [4, 7] show that waste/filter cake is characterized with a high value of swelling moisture (Tab. 2), what leads to high water absorption of dried to solid part ground. The swelling index value leads to a high swelling level (Tab. 2), [4, 5, 15], which results with big swelling in conditions advantage for moisturize changes.

3. MECHANICAL FEATURES AND FILTRATION

There were lead tests for compressibility and ultimate stress aimed at defining mechanical features of waste/filter cake samples [7].

Compressibility

Oedometric tests for waste samples compressibility was run according to standard the estimating process, on samples with diameter D = 65 mm and height h = 20 mm, putting it to normal stress valued in order: (12.5; 25; 50; 100; 200) kPa [4, 5, 7, 15]. The consolidation process of the waste/filter cake is shown in the consolidation curve (Fig. 4) [1], compressibility curve (Fig. 5) [1] and oedometric consolidation ground modules curve with normal stress (Fig. 6). The settlement curve (Fig. 7) shows the process of percentage decrease of sample height with normal weight increase.

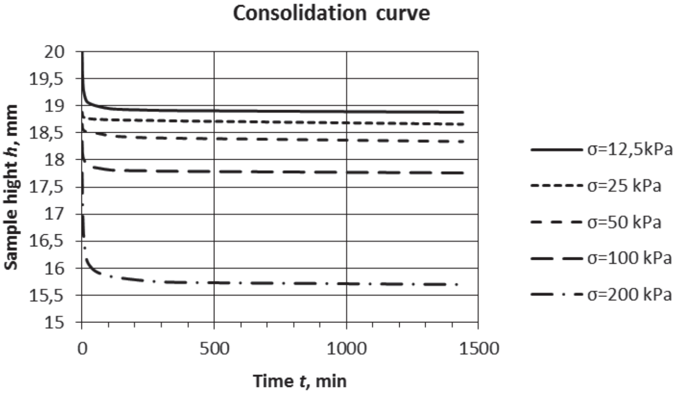

Fig. 4. Consolidation curves of waste/filter cake [1]

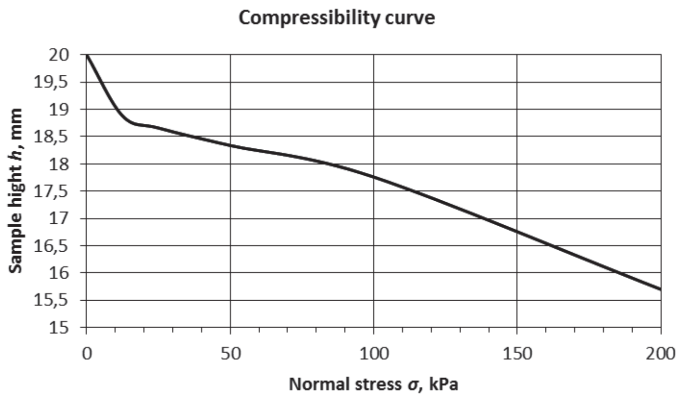

Fig. 5. Compressibility curve of waste/filter cake [1]

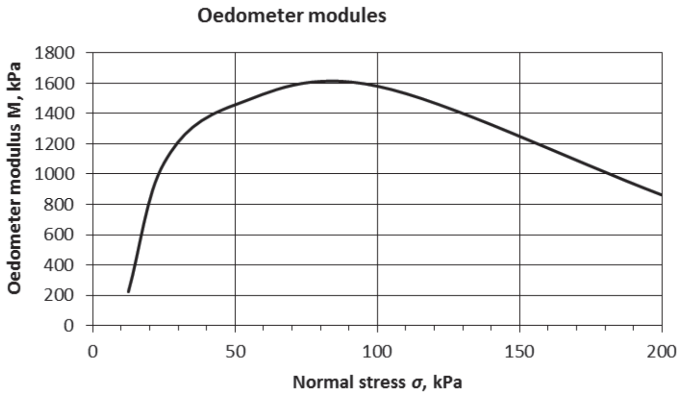

Fig. 6. Oedometric consolidation ground modules curve of waste/filter cake with normal stress increase

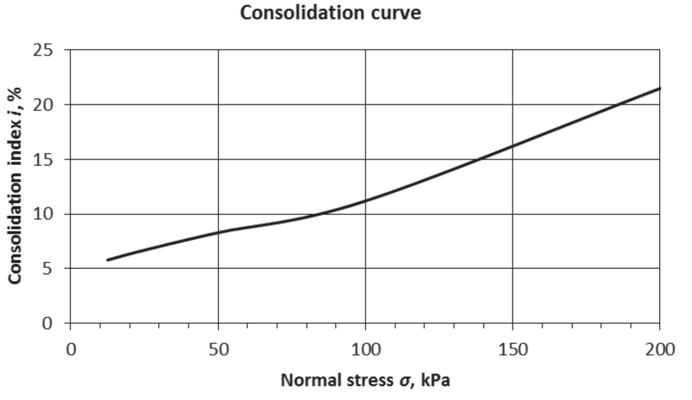

Fig. 7. Consolidation index decrease of waste/filter cake with normal stress increase

It was stated that after the stabilised consoldation of waste/filter cake, under stress σ = 12.5 kPa, the following consolidation process was less intense, in the range of stress (25 ÷ 100) kPa. Little normal stress resulted with slow water extrusion in the porous area of the ground. Increasing intensivity of ground subsidence was noticed after normal stress increase to σ = 200 kPa (Figs. 4, 5, 7). Following, also the ground edometric compressibility module value was decreased (Fig. 6).

As a result of lead tests, it was stated that waste/filter cake samples are highly sensitive to capacity decrease with normal stress increase. The maximum value of decreasing initial sample height, under stress σ = 200 kPa was over 21%, (Fig. 7).

Filtration

Filtration waste/filter cake's features were pointed by defining filtration coefficient values. Chart of filter coefficient values changeability, following ground normal stress increase is shown in Figure 8. Shape of filtration curie indicates an intensive decrease in filtration coefficient values in the tested ground with normal stress increase in the range of σ ϵ [12.5÷50] kPa. Under higher normal stress of ground's sample, decrease of filtration coefficient change intensity is noticed (Fig. 8).

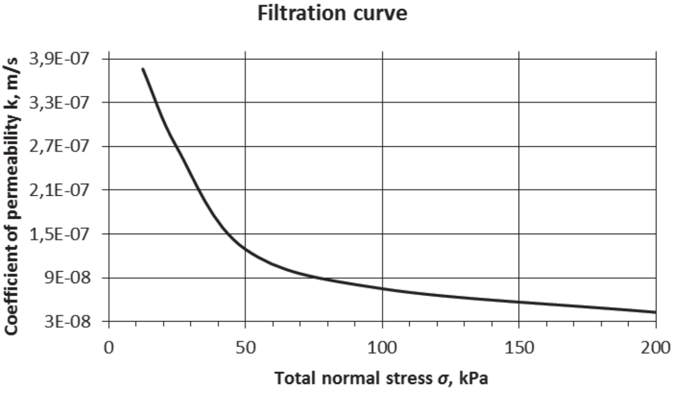

Fig. 8. Chart of waste/filter cake's filtration coefficient values change permeability with normal stress increase

It was stated that tests waste/filter cake, even compressed, do not accomplish standards for grounds used for creating gasket screens, due to overly large filtration coefficient values [6].

Shearing resistance

Testing shearing resistance of waste/filter cake samples was lead using the direct shearing method [7]. As a result, shearing resistance curve $\tau_f = f(\sigma)$ was delivered (Fig. 9). The linear regression equation indicates the shape of the mathematical model fitted to measure points, and the determination coefficient value R^2 shows the quality of its adjustment.

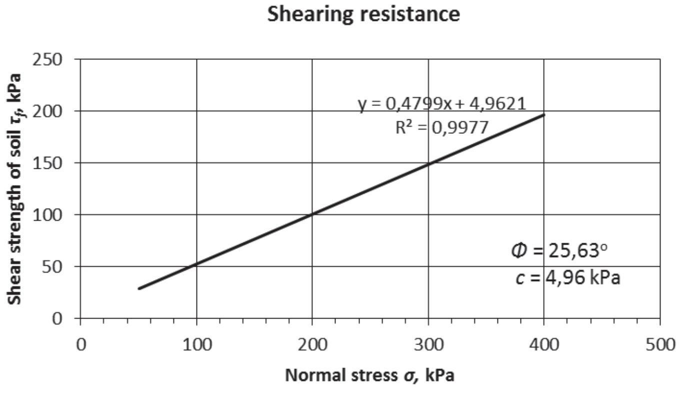

Fig. 9. Chart of waste/filter cake's shearing resistance: Φ – angle of shearing resistance, *c* – apparent cohesion intercept

Based on chart interpretation, shearing resistance angle ϕ and cohesion values of tested samples were defined (Fig. 9). It was stated, that the tested ground is characterized with law resistance parameter values.

4. CONCLUSIONS

1. Solid waste from processed drilling fluids filtration in the Factory of Ecological Labors in Tarnogród is very coherent fine-grained mineral ground with plastic consistence.
2. Tested waste/filter cake's samples are characterized with high water content and low bulk density values.
3. Filtered drilling fluid waste/filter cake is characterized with high swelling index value, which makes it expansive type of ground in water content changing conditions.
4. High swelling index value of waste/filter cake indicates high water absorption of tested soil.
5. Tested drilling fluid waste/filter cake show bug tendency for bulk density changes under normal stress.
6. Because of overly high filtration coefficients values, tested waste does not fulfill conditions for materials used in ground seal screens building.
7. It was stated that tested waste/filter cakes are characterized with low strength parameters. In need for using or safely depositing them, it is necessary to increase mechanical parameters tested waste.

5. DESIGNATION LIST

C_c – coefficient of curvature,
C_u – uniformity coefficient,
c – apparent cohesion intercept [kPa],
D – diameter of sample of soil [mm],

d – grain (particle) effective diameter, size of eye screen [mm],
E_p – swelling index [%],
h – height of sample of soil [mm],
Δh – increase height of sample of soil [mm],
I_C – consistency index,
I_L – liquidity index,
I_P – plasticity index [%],
i – consolidation index [%],
k – coefficient of permeability [m/s],
M – oedometer modulus [kPa],
R^2 – coefficient of determination,
t – time [min, day],
W – water (moisture) content [%],
W_{Ep} – swelling moisture [%],
W_L – liquid limit [%],
W_P – plastic limit [%],
x – independent variable,
y – dependent variable,
ρ – bulk density of soil [kg/m^3],
σ – total normal stress [kPa],
τ_f – shear strength of soil [kPa],
Φ – angle of shearing resistance [°].

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