ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 8 , August 2022

Evaluating the Effect of Cohesive Strength on Self-Leaching in Bonded Soils

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ABSTRACT: The results of experimental studies on the mechanical properties of cohesive soils associated with the use in the study of the erosion process have been presented. The influence of cohesion force of cohesive soil to erosion has been described. The relationship between the eroding water flow velocities and soil cohesion has been obtained.

KEY WORDS: soil cohesion, shear resistance, normal stress, angle of internal friction, cohesion force, tensile strength, flow velocity.

I. INTRODUCTION

The leaching rate of the stream, which evaluates the leaching process, is represented by a number of interacting and interrelated factors [1, 5, 8, 9]. In this research, we do not study the external, i.e., hydromechanical and other factors in depth, but we focus on the factors that are poorly covered in the literature related to this topic. Let's look at the shear resistance of soils, which is one of the important factors. Clarification of this factor is important in establishing effective improved methods for determining the flushing rate of water flow.

II. LITERATURE SURVEY

Maslov suggested using the following three-term formula instead of the two-term formula to determine the resistance to displacement [3]:

$$\tau = \sigma tg\varphi + C_k + C_c , \tag{1}$$

here σ - normal voltage; φ - angle of internal friction; C_k - joint of the rock with the property of recovery; C_c - structural cohesion due to irreversible bonds.

This formula shows two types of cohesion, namely cohesion C_k due to coagulation and cohesion due to solid C_c transitions and phase bonds. Cohesive strength under the influence of coagulant bonds is often determined in muddy soils during washing $C \approx C_k$. Therefore, the size of the joint depends on the density and moisture of the rock, the dispersion and hydrophilicity of the mineral rocks, the location of the particle in the shear plane, and other factors. In soils where phase bonds prevail, the structural cohesion is almost determined by C_c the magnitude depending on the wettability and composition of the soil. Structural cohesion in mixed-bond soils is determined by both components, i.e $C = C_k + C_c$. The strength of the structure $\sigma < P_c$ is important in case of C_k low normal loads C_c $\sigma > P_c$. From this, depending on the type of structural connection in clayey rocks, not only the size, but also the nature of structural connection changes [6].

III. METHODOLOGY

It is possible to analyze the relationship between the angle of internal friction and the character of the structural bond. The formation of structural bonds in underwater conditions begins with the processes of coagulation and aggregation that

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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occur during the deposition of thinly dispersed minerals. Here it should be noted that close and distant coagulation bonds can be formed depending on the size and shape of particles, their surface potential, relative hydrophilicity, concentration and composition of the solution in the cavity, and their mutual determination in the dispersed medium [4].

Sections of many canals are located on bound soils, i.e. sandy, loamy and silty soils. These primers are solid, plastic and liquid depending on their moisture retention. Because bonded grouts are cohesive, they resist shifting and stretching. The ultimate resistance of soils σ_c is divided into ultimate resistance against displacement and ultimate resistance σ_p against elongation. σ_c ultimate shear resistance and σ_p tensile ultimate resistance have interrelated definitions and can be determined using the same test methods for grouts. This can be determined, for example, by the ball sampling method.

The tensile resistance of bonded soils σ_p is much smaller than the shear resistance σ_c , and according to Ts. E. Mirtskhulava [5], it is equal to the values for soils with an aggregate structure $(0,15 \div 0,18)\sigma_c$ and for soils with an integrated structure $(0,20 \div 0,22)\sigma_c$. It can be considered as $\sigma_p = 0,18\sigma_c$ the dynamic tensile strength σ_p . Hence, shear strength is the main strength σ_c characteristic for bonded soils. To determine the cohesion of water-saturated soils, the following relationship was obtained [1]:

$$\sigma_c = 10^7 \frac{W_p^4}{\varepsilon_n^3}, \qquad (2)$$

here W_p - humidity of the ground at the limit of massing (rolling out) (the ratio of the mass of water in the sample to the dry mass of the ground); ε_n - porosity coefficient.

IV. EXPERIMENTAL RESULTS

According to the data of the experiments carried out by us on the bonded soil samples, the dynamic strengths in displacement σ_c and elongation σ_p were determined (Table 1).

Sandy soil 6 does not have dynamic stability in shear σ_c and extension σ_p due to the high content of fine sand. At the beginning of the formation of cohesive soils at the bottom, the fluid cracks are filled by coagulation, and then sedimentation and permanent consolidation of the sediments occur, and this process leads to the formation of the fissured cell structure of the soils. In such soils, the particle size $d < 10^{-5}$ m is very small, their porosity coefficient $\varepsilon_n > 1 \div 1,5$ and moisture content are 80-85%, and they are called clays.
We know that highly water-saturated clays produce a fluid visco-plastic environment that does not obey Newton's law:

$$\tau = \tau_b + \mu_{э\phi} \frac{d\bar{u}}{dz}, \qquad (3)$$

where τ is the tensile stress between the moving layers; τ_b - initial shear stress; $\mu_{э\phi}$ - effective viscosity.
The effective viscosity can be determined by the following formula:

$$\mu_{э\phi} = \mu\left(1 - ac^n\right)^n, \qquad (4)$$

here a and n -parameters.

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Table-1. Dynamic strengths in σ_c shear and elongation σ_p

№	Sample ground	C, $кг/см^2$	υ_p, $м/с$	$\upsilon_{кр}$, $м/с$	d	i	U_*	$\sigma_c = 10^7 \frac{W_p^4}{E_n^3}$	$\sigma_p = 0{,}18 \cdot \sigma_c$
1	2		4	5	6	7	8	9	10
1	Ground-1	0,094	0,67	0,48	0,004	0,003	0,0108	0,004*10^7	0,00072*10^7
2	Ground-2	0,088	0,51	0,36			0,0108	0,001*10^7	0,00018*10^7
3	Ground-3	0,084	0,67	0,48			0,0108	0,0007*10^7	0,000126*10^7
4	Ground-4	0,068	0,5	0,36			0,0108	0,0005*10^7	0,00009*10^7
5	Ground-5	0,043	0,45	0,32			0,0108	0,0006*10^7	0,000108*10^7
6	Ground-6	0	0,47	0,34			0,0108	-	-

According to experimental experiments [1] $a = 1{,}58$ and $n = 0{,}175$ acceptable. According to Mirtskhulava's experiments, it is equal to $a = 1{,}3$. We now consider the effect of bond strength on bond grouts against leaching. Bonding forces in bonded primers have a very complex nature and are determined by the following internal bonds: intermolecular-contact; colloidal structure; with cementation [3, 4, 5, 6, 7]. If the bound soils are saturated with water, then the cohesive forces increase their resistance to being washed away by the flow, and these forces determine their degree of consistency. .

We conducted experiments in the laboratory of "UzGAShKLITI" LLC (State Project-Research Institute of Construction, Geoinformatics and Urban Development Cadastre) to determine the cohesive strength of soil samples prepared for the study of the washing of bound soils under the influence of currents. Based on the experimental data, we will consider the impact of the bonded soil on the shear resistance (Table 2).

According to Table 2, we construct a graph of the relationship between shear strength and normal stress (Fig. 1) and analyze it according to the relationship. From Table 2, with the increase of the friction force C, the value of the shear strength τ also increases. Since the experiments were carried out under conditions of slow consolidation shear, the relationship $\varphi = f(\sigma)$ takes on a straight line, and the value of the coefficient φ increases. φ the following reasons can be given for the increase of the coefficient:
- reduction of the hydrated film layer in coagulating contacts and increased molecular interaction between particles when squeezing water from the system;
- an increase in the number of contacts.

Table-2. Shear resistance of bonded grounds.

№	Sample ground	σ	$tg\varphi$	C	$\tau = \sigma tg\varphi + C$
1	2	3	4	5	6
1	Ground-1	1,194	27	0,094	0,703
2	Ground -2	1,113	27	0,088	0,656
3	Ground -3	1,063	26	0,084	0,579
4	Ground- 4	1,025	25	0,068	0,545
5	Ground -5	0,956	25	0,043	0,488
6	Ground -6	0,191	10		0,034

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 8 , August 2022

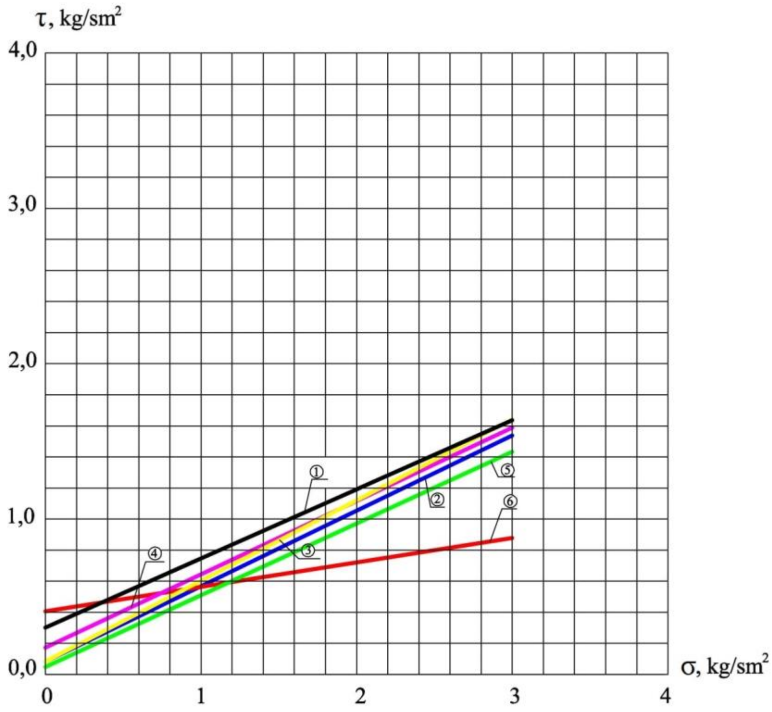

Figure-1. $\tau = f(\sigma)$ **bond graph: plot 1; 2nd ground; 3rd ground; 4th ground; 5th ground; Ground 6.**

Therefore, in clayey rocks with strong phase contact, the connection $\tau = f(\sigma)$ has a straight-line appearance, and its angle of inclination with respect to the abscissa axis does not depend almost on the experimental conditions. Because these mudstones have a high degree of strength, their angle φ is much higher (Fig. 1).

The flowability of bonded soils depends largely on their cohesive strength. The cohesive strength of bonded primers when fully saturated with water often determines the degree of bond strength and is distinguished by priority over other physico-mechanical properties of bonded primers that resist leaching.

To show the priority of this factor, we will analyze the laboratory data (Table 1) on the determination of the bond strength of bonded soil samples. In bound (sand, loam) soils with an aggregate structure, leaching occurs as a result of the disruption of the interconnection between the aggregates. It should be noted that the size of the released aggregate particles is determined by the structure and intensity of water flow turbulence. Disruption of aggregates in almost flat channel beds occurs only under the influence of pressure pulsation force, and it can be defined as follows [2]:

$$p' = 3,5\rho u_*^2, \qquad (5)$$

here u_*-is the dynamic flow rate.

The variable dynamic pressure, which depends on the effect of pulsating pressure, leads to a violation of the bonding properties between aggregates. As a result, it always creates conditions for the occurrence of micro-cracks. At this time, aggregates can stay in place only under the influence of their own gravity. The resulting pressure pulsations cover a large part of the surface of the bottom of the well. It is in this case that the value of the standard pulsation of the pressure on the surface of the soil aggregate is so small that it can be neglected. If the negative pulsating pressure force on the surface of the aggregate is equal to the gravity force acting on the aggregate, leaching of the bound soil occurs. We express this mentioned condition in the following form:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 8 , August 2022

$$p' \cdot d_a^2 = (\rho_s - \rho) g d_a \cdot d_a^2, \qquad (6)$$

here d_a - is aggregate size.
(5) taking into account the magnitude, we write the equation (6) in the following form:

$$3,5 \rho u_*^2 d_a^2 = (\rho_s - \rho) g d_a^3 , \qquad (7)$$

ρ_s - is soil density.
(7) it is possible to find the sizes of aggregates breaking from equality, i.e

$$d_a = \frac{3,5 u_*^2}{g\left(\dfrac{\rho_s}{\rho} - 1\right)} . \qquad (8)$$

According to laboratory experiments, the sizes of the aggregates $u_* = 10 \div 15 \ см / с$ that break off at dynamic speed velocities are approx, $d_a = 3 \div 4 \ мм$. From this we can see that the process of failure of bonded soil associated with turbulent flow is always dependent on factors other than the adhesion force.

Now, on the basis of the experimental data, we will establish a connection between the strength of the soil, which is connected with the washing speed of the stream (Fig. 2).

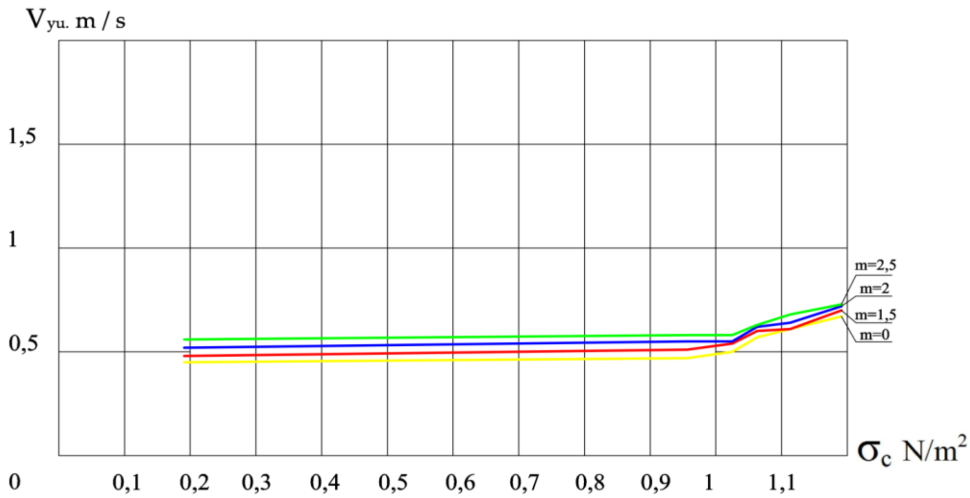

Figure-2. $\upsilon_p = f(\sigma_c)$ connection graph

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 9, Issue 8 , August 2022

The relationship graph shown in Figure 2 shows $\upsilon_p = f(\sigma_c)$ the condition for determining the flow wash rate versus the dynamic shear strength parameter. We also plot a graph of the connection $\upsilon_p = f(C_b)$ between the washing speed of the flow υ_p and the cohesive strength of the bonded soil C_b according to the experimental data.

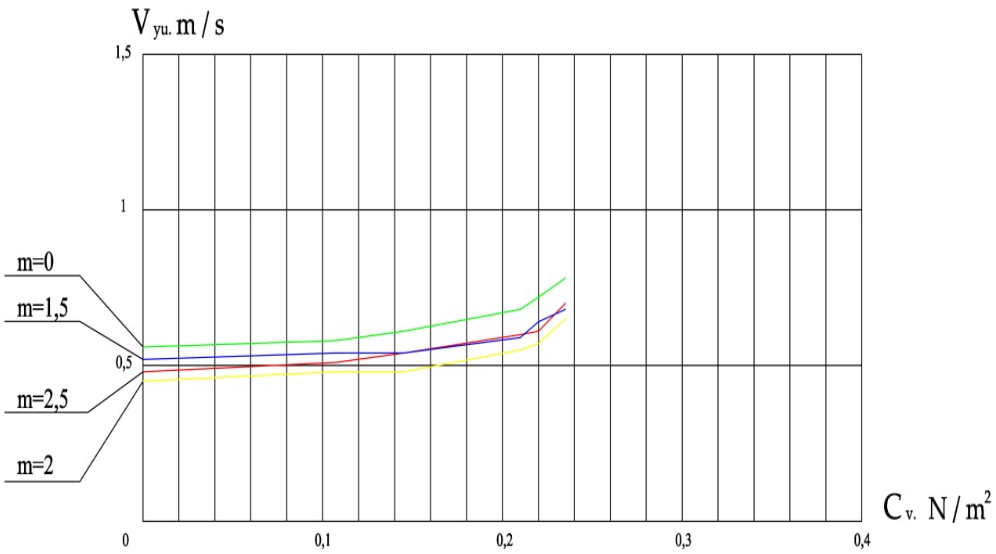

Figure-3. $\upsilon_p = f(C_b)$ connection graph

V. CONCLUSION

In laboratory and field conditions, it was observed that the leaching resistance of bonded soils increased with increasing bond strength. Evidence of this can also be seen in the connection graph $\upsilon_p = f(C_b)$ shown in Figure 3.

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