On the establishment of the correlation dependence of results of physical properties, dynamic probing and filtration coefficient from the granulometric composition of alluvial sands in the valley of the Amudarya river

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Abstract. Based on the study of the mechanical composition and physical properties of alluvial sands, the correlation equation necessary for engineering and geological studies to analyze the lithological conditions of the soils, the average physical properties of the Amudarya river and soils, and the average number of strokes per 1 dm immersion probe are studied. Quantities of definitions are represented in large numbers. The study of the physical properties of the sand of both terraces is complicated by the very close occurrence of the groundwater level. Above and near the groundwater level, physical properties were studied in pits, some of which were drilled. Samples of undisturbed sand were taken with a 700 cm³ cutting cylinder. The volumetric weight of the skeleton of both terraces in natural addition is the same for species with the same particle size distribution (1.30 - 1.50 g/cm³). The geological structure was studied in wells that were drilled by a rope method. Samples were taken from these wells to determine the particle size distribution of the sand. The mineral composition of sand and clay determines the nature of their resistance to shear, and clay soils are characterized by resistance to uniaxial compression and rupture.

1. Introduction

1.1 General information

The described area covers part of the Amu Darya river within the village of Mukry-Kerkichi The alluvial sands of the Amu Darya complex (alQ⁰ - the first terrace, alQ⁴ - the second terrace) with a thickness of 20-30 m on the first terrace and 10-15 m on the second terrace mainly participate in the geological structure of the modern valley. The same deposits serve as the basis for most hydraulic and irrigation structures under construction, and therefore the study of their properties is relevant. Visually, the sands of both terraces are relatively identical, gray micaceous, quartz-feldspar composition, thin-layered. According to the granulometric composition, the sands of both terraces are from dusty to medium-sized, with different-grain (small and medium) differences prevailing [1].

As an illustration, Table 1 gives the particle size distribution of sand in rounded percent.
action <0.1 mm and, to a lesser extent, the content of fractions greater than 2 mm is very significant.

The content of fractions of steady motion. Despite some limitations, the soil skeleton increases equally with the size modulus in both sand terraces, then the average mechanical and filtration properties are determined not only by the size of the predominant fractions.

A more detailed analysis of the granular composition of the sand shows that their physical and mechanical properties are determined not only by the size of the predominant fractions.

| № | Fractions mm       | 2.0 | 2-1 | 1-0.5 | 0.5-0.25 | 0.25-0.1 | 0.1 |
|---|--------------------|-----|-----|-------|----------|----------|-----|
| 1 | Dusty              | -   | -   | 1.0   | 0.5-1.0  | 2.1-15.0 | 75-95 |
| 2 | Grained (small, thin) | 2.0 | 0.1-2.0 | 0.5-10 | 2.0-30 | 10-60 | 10-40 |
| 3 | Small              | 2.0 | 0.1-5.0 | 0.5-10 | 10-40 | 60-90 | 5-15 |
| 4 | Miscellaneous (small, medium) | 1.5-15 | 1.5-5.0 | 2.0-10 | 20-60 | 20-60 | 1.5-10 |
| 5 | Medium size        | 5-15 | 2.5-10 | 5.0-25 | 30-65 | 10-30 | 0-2.0 |

It should be noted that in the sands of the second terrace, variegated (large and medium) and medium-sized varieties are less common than in the sands of the first terrace. According to single analyzes, sands contain 50-60% of quartz, 20% of feldspars, and grains of carbonate rocks, about 5% silicon, mica contains about 1% less often up to 3%. Sands are in a water-saturated state (the groundwater level on 1 terrace lies at a depth of 1-2 m, and on the second terrace at a depth of 2-5 m).

Water permeability is very high (on the 1st terrace $Kf$ varies from 5 to 150 m / day, in most cases 30-70 m / day; on the 2nd terrace $Kf$ varies from 2 to 100 m / day, often 15-30 m / day) and fluctuates over a wide range[2]. To clarify the mechanical properties, the dynamic sounding of the sands of the UBP-15 machine tools was carried out according to the Hydro project using a hammer weighing 60 kg, falling from a constant height. The probing was carried out with conical tips with an angle at the apex of 60 °, a diameter of 74 mm and a height of 94 mm with a ratio of the diameters of the cone and the rod 2:1[3]. The verticals of dynamic sounding included data on the granular composition and filtration properties of the sands, as well as to correlate the results obtained near the pits (vertically near each wall), from which samples of the undisturbed structure were taken[4].

The water permeability of the sand was determined by single and cluster pumping, mainly from imperfect wells equipped with filters with a brass grid and behind a pipe piezometer. The calculation of the filtration coefficient was carried out according to the formulas of steady motion. Despite some complexity of the ratio of indicators of various properties to one point in the section, the result of the data shows that both in the sands of the first terrace and in the sands of the second terrace there is a very clear dependence of the volumetric weight of the soil skeleton $\gamma$, t/m³, the filtration coefficient $Kf$, m/day and resistance to clogging of the cone $Nav$ from particle size distribution (the generalized characteristic of the grain composition used the size modulus, expressed as the ratio of the percentage of intensive fraction volume <$0.1$ mm to 100% of the rock volume) [5]. At the same time, the different nature of this dependence is noted in the sands of the second terrace. If the volumetric weight of the soil skeleton increases equally with the size modulus in both sand terraces, then the average number of strokes per 1 dm of probe immersion ($Nav$) in the sands of the first terrace is lower and the filtration coefficient is higher than in the second sand with the same composition and density terraces [6].

2. Materials and methods
This phenomenon is explained by the fact that the older sands of the second terrace have a greater “hardening adhesion” (according to the [1] terminology of N. Ya. Denisov) than the younger sands of the first terrace.

“Strengthening adhesion” will determine the building properties of sand, such as, for example, their dynamic stability, deformation modulus, and shear resistance. The presence of a “hardening bond” indicates the presence of structural bonds in the sands[6].

A more detailed analysis of the granular composition of the sand shows that their physic mechanical and filtration properties are determined not only by the size of the predominant fractions. The content of the fraction <$0.1$ mm and, to a lesser extent, the content of fractions > 2 mm is very significant.
Based on the totality of these indicators of the current (d10) controlling diameters (d60) in the alluvial sands of both terraces, it turned out to be possible to distinguish 4 groups with different physical, mechanical and filtration properties (Table 2).

As noted above, the study of the engineering and geological properties

3. Results and discussion

Therefore, we have processed all parallel definitions of various soil properties by the method of mathematical statistics [14].

Table 2. Dependences of the physicomechanical and filtration properties of alluvial sands

| Sands groups by granulometric composition | floodplain | floodplain | floodplain | floodplain | floodplain |
|------------------------------------------|------------|------------|------------|------------|------------|
|                                           | terrace    | terrace    | terrace    | terrace    | terrace    |
| The average number of strokes per 1 dm of probe immersion | 1.5 – 4.0 | 1.5 – 5.0 | 4.0 – 6.0 | 5.0 – 10.0 |
| most often                                | 2.5 – 7.0  | 6.0 – 9.0  | 9 – 20     | 10 – 50    |
| 2 – 3                                     | 3 – 4.5    | 4.5 – 5.5  | 57 – 20    | 51         |
| Number of Definitions                     | 43         | 49         | 57         | 51         |
| Volumetric weight of the skeleton of the soil in natural composition, t / m³ | 1.30 – 1.40 | 1.40 – 1.45 | 1.45 – 1.55 | 5 – 15 less common |
| 1.30 – 1.40 | 1.40 – 1.45 | 1.45 – 1.50 | 5 – 15 less common |
| Number of Definitions                     | 34         | 22         | 10         | 14         |
| Filtration coefficient Kf, m / day        | 5 – 15     | 15 – 30    | 20 – 50    | 70 – 150   | 50 – 100   |
| less commonly                             | 2 – 10     | 10 – 30    | 20 – 50    | 70 – 150   | 50 – 100   |
| Number of Definitions                     | 5          | 6          | 2          | 11         | 1          |

According to these data, we calculate the parameters of the linear correlation dependence, where the sums of the individual parameters are equal to [13]:

\[ \sum X_M k = 155.31; \quad \sum Y_N Av = 560.35; \quad \sum X_M 2 = 258.71; \]

\[ \sum Y_N Av = 2322.67; \quad \sum X_Y M k N a v = 796.54; \]

Using the formula of the linear correlation coefficient:

\[ R = \frac{\sum X Y - \sum X \sum Y}{\sqrt{\left[ \left( \sum X^2 - \left( \sum X \right)^2 \right) \left( \sum Y^2 - \left( \sum Y \right)^2 \right) \right]} = 0.43 \]

(1)
we estimate the tightness of the linear connection, because $R > 0$ there is a direct connection between $M_k$ and $N_{av}$. To assess the reliability of the correlation coefficient, we use the ratio of the correlation coefficient $R$ to its error $\eta$.

The average error of the correlation coefficient is calculated by the formula

$$\eta = \frac{1 - R^2}{\sqrt{\Pi}} \quad (2),$$

Where $\eta = 0.081$.

If the ratio $\frac{|R|}{\eta} (3)$; then the linear relationship can be considered proven.

In our case, this relation $\frac{0.43}{0.081} = 5.3$

Substituting the sums of values $\sum X M_k = 72.26$; $\sum Y M_k = 1862.97$; $\sum X M_k^2 = 130.15$; $\sum Y K f^2 = 115363.21$; $\sum X Y M k K f = 3491$, formulas we calculate the parameters “a” and “b” of the correlation equation $u = a x + v$

$$a = \frac{\sum Y u - \sum x \sum v}{\sum x^2 - (\sum x)^2} = 49.1 \quad (4)$$

$$v = \frac{\sum x^2 \sum u - \sum x \sum vx}{n \sum x^2 - (\sum x)^2} = -40.2 \quad (5)$$

The correlation equation has the form

$K f = 49.1 \quad M k = 40.2$

$R = 0.67$

Therefore, the correlation equation should be considered proven[8].

V. A. Durante | 1 |, who studied the geotechnical properties of sand by dynamic penetration and as a result of processing data by mathematical statistics, proposes a regression equation to determine the volumetric weight of sand from the number of hits per 10 cm ($N$) of probe immersion, for alluvial sand with undisturbed addition, in the form of

$$\sigma = 0.0086 N + 1.495$$

When checking this data with our formula, it was found that the volumetric weight of the soil, calculated according to this equation, slightly exceeds the actual indicator of this value[10].

The reason for this discrepancy is that the sands of the Volga river valley in their structure or formation conditions differ from the sands of the Amudarya River valley[11-20].

When processing 31 parallel data of the volumetric weight of the skeleton and the average number of strokes, the following correlation equation is obtained

$$\gamma = 0.0285 N_{cp} + 1.298$$

4. Conclusions

The obtained correlation equations and the dependency table are of great applicability in the practice of engineering and geological research in river valleys and will make it possible to obtain all other engineering and geological indicators of sand from one well-known characteristic.

References

[1] Gapparov F A Mamatov S A 2010 Factors Affecting the Reliability of Reservoir Operations “Ecological and Geographic Aspects of the Use and Protection of Natural Resources in the Single Natural Historic Area” (Ferghana) pp 108-109

[2] Bakiev M R 2018 Analyzing problems of unsightly and unsafe exploitation of water plots in water Journal of Irrigation and reclamation (Tashkent) No 3(13) pp 10-13

[3] Mahmudov E J Paluanov D T 2017 The organization of monitoring of the quality of the search and maintenance of water objects The journal of practical work "Put the power of the oroshenaemogo zemledeliya" No 3(67) (Novocherkassk) pp 134–139

[4] The safety of hydraulic structures in Central Asia: problems and approaches to their solution 2011 (Almaty) p 37

[5] Bellendir B N Solsky S V Nikitin N Ya 2000 Methodological foundations, analysis and risk assessment of accidents of soil dams in the Russian Federation News of VNIIG named after B E
(Vedeneva) T 238 pp 15-19
[6] Volosukhin V A 2019 On problematic issues in the field of safety of hydraulic structures Monitoring: Science and security Special issue pp 84-97
[7] Volosukhin V A Volosukhin Y V 2010 Normative, legal and technical regulation in the field of safety of hydraulic structures Journal "Hydrotechnics" (Moscow) No 1 pp 22-30
[8] Gapparov F A Narziev Zh Zh 2018 Reservoir Flood Forecasting and Prevention “Improving the efficiency, reliability and safety of hydrotechnics facilities” mausoleum International scientific-practical conference
[9] Gapparov F A Narziev J J 2018 Predicting and preventing reservoir overflow International scientific-practical conference on "Improving the efficiency, reliability and safety of hydraulic structures" (Tashkent)
[10] Gapparov F A Mamatov S A 2010 Factors Affecting the Reliability of Reservoir Operations “Ecological and Geographic Aspects of the Use and Protection of Natural Resources in the Single Natural Historic Area” (Ferghana) pp 108-109
[11] Gapparov F A Nazaraliev D V Narziev J J 2017 Organization of safe and efficient use of reservoirs International scientific-practical conference (Tashkent)
[12] Irisboev Z 2019 Ensuring the safety of large and especially important hydraulic structures Journal "Uzbekhydroenergy" (Tashkent) No 3 pp 18
[13] Kuleshov G N 2009 Recommendations for assessing and ensuring the safety of hydraulic structures (Tashkent) p 224
[14] Mirtskhulava Ts E 2008 Approaches to assessing the aging measures of long-term operated dams Journal of Hydrotechnical Construction (Moscow) No 6 pp 41-49
[15] Paluanov D T 2019 The problem of design and construction of low-pressure hydraulic structures in complex construction and geological conditions Scientific-methodical journal "Problems of modern science and education" (Moscow) No 3(136) pp 14-17
[16] Paluanov D T Makhmudov A A 2019 Prospects for the development of science in the XXI century and the role of innovations in them" Proceedings of the 8th republican online conference on "Some aspects of ensuring the safety of hydraulic construction in-oilization" (Tashkent) 2 ies pp 191-193
[17] Gapparov F A Yangiev A Adjimuratov D 2019 Filtration process in earth fill dam body and its chemical effect on piezometers E3S Web of Conferences EDP Sciences 97 05032
[18] ICOLD 1995 Dam failures-statistical analysis № 99 (Paris)
[19] Yangiev A A 1991 Evaluation of the energy-extinguishing ability of the elements of the discharge path of high-pressure vortex spillways Abstract dis MGMI p 19
[20] Yangiev A A Khamidov A 2006 Swirling flow of aerated flow in a semi-bounded cylindrical pipe Republican scientific-practical conference "Problems of reliability and safety of hydraulic structures" November 22-23 (Tashkent)