Study of sandy soil grain-size distribution on its deformation properties

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Abstract. As a rule, new oil and gas fields’ development faces the challenges of providing construction objects with material and mineral resources, for example, medium sand soil for buildings and facilities footings of the technological infrastructure under construction. This problem solution seems to lie in a rational usage of the existing environmental resources, soils included. The study was made of a medium sand soil grain-size distribution impact on its deformation properties. Based on the performed investigations, a technique for controlling sandy soil deformation properties was developed.

1. Introduction
According to the existing regulations, the soil base works have to be carried out at the early stages of buildings and facilities construction [1]. For example, when constructing oil and oil products storage tank, one needs to perform an operation cycle on soil base arrangement. Specially prepared medium sandy soil is used for this application. But this requirement cannot always be met due to remoteness of the sandy soil with a necessary grain-size distribution from the object under construction. The necessary materials delivery may require substantial material and time expenses, causing a significant increase in the costs of the constructed object. Apparently, the sustainable use of the existing local resources, soil included, may significantly affect the decrease in time and material costs at the construction stage of oil and gas industry facilities.

2. Problem statement
The dependence of the existing technologies for building and facilities soil bases arrangements is problematic to decrease. This problem solution appears to lie in developing an auxiliary specialized technique aimed at controlling the deformation properties of the present sandy soil. The main objective of the performed investigation is to specify the impact nature of the sandy soil grain-size distribution on its deformation properties. To achieve the formulated task, the following problems are to be solved:

- to study deformation properties of medium sandy soil;
- to study deformation properties of separate sand fractions;
- to develop the technique for altering the soil deformation properties on the basis of the obtained results.
3. Laboratory investigations

At the early investigation stage, the type of the sandy soil was defined according to the existing classification [5]. A sieve analysis is used to determine the grain-size distribution of the sandy soil. This analysis is performed by screening the sandy soil through a column of laboratory sieves (figure 1a) arranged in the order of mesh size increase from 0.1 mm to 10 mm. The weight percentage of the separated fractions determines the type of sand (figure 1b).

![Figure 1](image1.png)

**Figure 1.** Preparing the sandy soil to compression tests:

a) laboratory sieves; b) fractions of the sandy soil.

In previously performed investigations the nature of sandy soil humidity effect on its deformation properties was determined [7]. Laboratory tests were performed on automated test complex ASIS, and they allowed characterizing the humidity effect on the deformation properties of separate sandy soil fractions.

![Figure 2](image2.png)

**Figure 2.** Automated test complex ASIS.

Automated test complex ASIS includes:
- an axial loading device (figure 2a);
- measuring system ASIS (figure 2b);
- an odometer (figure 2c).

A special loading programme was developed to carry out compression tests for a sandy soil sample. The maximum load on the sandy soil sample under the test is equivalent to the pressure under a
50000 m³ tank bottom during its hydraulic tests. The test procedure includes soil sample step loading with a time exposure at each step, and subsequent step unloading of the investigated sample.

4. **Laboratory findings**

In the course of the performed investigations a technique was developed, that included the following stages:

- preparatory stage (soil fractionating, determining the soil bulk density and humidity, adding necessary amount of water into soil and its mixing);
- principal stage (soil humidity control, compression tests);
- final stage (laboratory data processing, conclusions and recommendations).

Medium sandy soil from the Irtysh river floodplain was used as initial soil. During compression tests, the dependencies of sandy soil humidity effect on its deformation properties were determined. Figure 2 represents the dependence for vertical deformation of the medium sand sample with the height of 25 mm on its humidity.

![Figure 2](image)

**Figure 2.** The results of compression tests performed on the medium sandy soil.

As the diagram shows, there is a humidity range with noticeable maximal vertical deformation of the sandy soil sample. The sharp increase is observed at the range from 0 % to 3 %, while at humidity more than 15 % there is a decrease.

These dependencies were received for sandy soil fractions with the grain sizes of 0.5-1.0 mm, 0.25-0.5 mm, 0.1-0.25 mm and for the fractions less than 0.1 mm. The resulting characteristics will enable the synthesis of the soil with predetermined mechanical properties.

Based on the data from [8, 9], the technique was proposed to adjust the deformation properties of loose dispersive soil having a number of advantages in comparison with traditional ones, namely, the decrease in material and time expenses. This technique calls for application of neither expensive components nor specialized equipment.
The dependence of sandy soil vertical deformation on humidity for its different fractions.

The proposed technique consists in fractionating sandy soil, determining deformation properties of each one, and then creating a composite mixture with predetermined mechanical properties.

5. Conclusions
Therefore we may draw the following conclusions:
- the technique for performing laboratory tests is developed;
- the deformation properties of medium sand soil as well as its separate fractions were studied;
- the sand soil deformation properties control technique was developed;

The developed technique has been granted a patent [10].

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