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Research Article

The Choice of the Type of the Natural Foundation for the Facilities of a Rotational Complex in the Area for the Oil Pumping Station Yugan of the Tyumen Region

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ABSTRACT.

The article is devoted to the problem of choosing a natural soil foundation for a rotational complex in the SurgutskyDistrict of the Khanty-Mansi Autonomous District of the Tyumen Region. The modern classification of the types of natural foundations is considered. The engineering-geological features of the territory, associated with an exceptionally plain ground and the wide distribution of finely-dispersed, silty lacustrine-alluvial sediments are analyzed. For two wells, the graphs of changes in the properties of the soil in accordance with the depth were compiled as: density, indices of liquidity and plasticity, modulus of total deformation, adhesion and the angle of internal friction. A layer-by-layer analysis of the lithological section made it possible to identify that the most favorable natural foundation for the facilities of a rotational complex is sand, the depth of occurrence of which is 11.5-18.0 m. Considering the depth of the sand layer, the most acceptable type of the foundation for the facilities of a rotational complex will be the pile foundation.

Keywords: Natural foundation, Engineering structure, Soil, Loam, Sand, Index of liquidity, Index of plasticity.

INTRODUCTION

In Western Siberia, more than 500 fields of oil, gas,and gas condensate have been discovered. The engineering-geological surveys, competently performed in the development of fields, are one of the pillars of the safety of the process of oil and gas production and the durability of the facilities at the fields.

An important point in the development of fieldsis the preparation of territories and the justification of construction projects. These tasks are complicated by the fact that most of the hydrocarbon deposits are located in the Khanty-Mansiand Yamalo-Nenets Autonomous Districts, that is, in the process of conducting surveys, geological engineers need to explore areas where specific soils are common and engineering-geological processes are well developed [1].

The natural foundation for an engineering structure is those rocks that accept the loads from buildings and structures. If the rocks are not sufficiently dense and strong, they are artificially improved. If the foundation is built on bulk or alluvial (artificial) soils, then those soils are called an artificial foundation [2,3].

Rocky and semi-rocky soils are a reliable foundation. In Western Siberia, they are located at great depths. Therefore, geological engineers in Western Siberia have to work with natural foundations, represented only by dispersed rocks.

METHODS

To select the natural foundation for the structures of a rotational complex, 28 wells were drilled at the survey site, the samples of soil and groundwater were collected, and the laboratory examinations of soil and groundwater were conducted. The indicators of physical and physical and mechanical properties obtained in the laboratory made it possible to compile the graphs of changes in the properties of the soilin accordance with the depth for two wells, which are characterized by the most complex engineering-geological conditions. The data were used on the change in soil density, the index of plasticity, the index of liquidity,the modulus of total deformation, adhesion and the angle of internal friction. The full range of physical and mechanical properties of the soil was determined by conducting compression tests under loading. All laboratory and field studies were conducted in accordance with the regulatory documents in force in the Russian Federation for 2018 in the field of engineering-geological surveys, prescribed in the Code of Practice 47.13330.2012 "Engineering Surveys for Construction. The Main Provisions"[4] and the Code of Practice 11-105-97 "Engineering-Geological Surveys for Construction"[5].

RESULTS

The analysis of the engineering-geological conditions of the construction site (the state and properties of soils, hydrogeological, geomorphological) allowed recommending sand as a natural foundation. The depth of its occurrence ranges from 11.5 m to 18.0 m.

DISCUSSION

In nature, rocks are very diverse in their origin, conditions of occurrence, composition, structure, physical state and properties. Therefore, their behavior under the influence of buildings and structures is different. In this regard, it is necessary to identify certain types of natural foundations (Fig. 1), as a basis for which it is recommended to use the engineering-geological classification of rocks [3]. The classification includes loose non-coherent rocks (medium-sized sands, coarse, as well as gravel, rubbly sands and pebbles of dense and medium density of consistency), fine and silty quicksands of low density of consistency, soft, cohesive clay rocks of low humidity, dense and withelevated density, with stable consistency, the variation of clay rocks of unstable consistency.

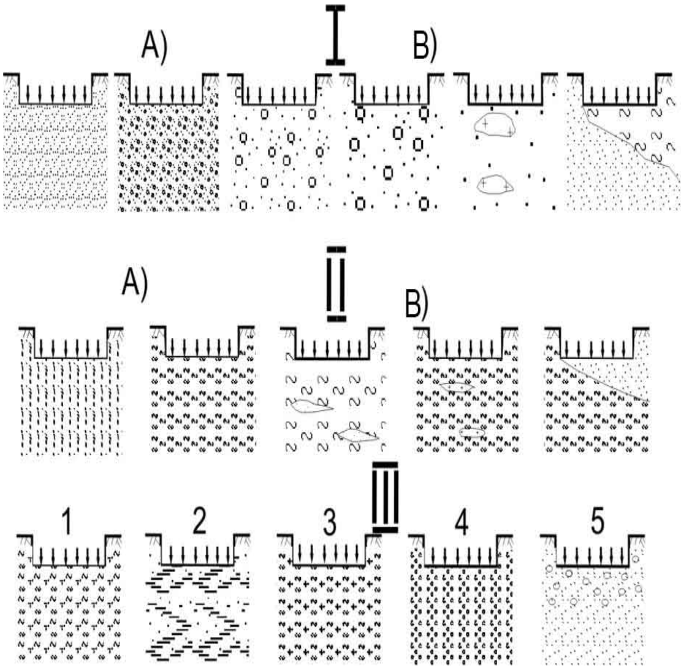

Fig. 1 Types of the natural foundations of the bases of buildings and structures in homogeneous (A) and heterogeneous (B) rocks.Type codes:I-III – rocks: I – loose non-coherent; II – soft cohesive; III – of special composition, state and origin (1 – peat, 2 – quicksand, 3 – frozen clay, 4 – salt, 5 – bulk).

In addition to the above-mentioned sandy and clay rocks, there are other various weak rocks: peatlands, silts, chemical highly soluble sedimentary rocks (gypsum, anhydrite, rock salt).

In the design and construction of civil and industrial buildings, it is necessary to strive to ensure that they are based on the densest and most durable rocks [6-8], which are fairly uniform in size and the depth of the zone of their influence.

In accordance with the scheme of engineering-geological zoning of the West Siberian geosyneclise, the examined area corresponds to the area of flat periglacial lacustrine-alluvial middle Pleistocene plains.

The examined area is located on a lacustrine-alluvial plain. There are quaternary deposits in the zone of influence of the structures. Lacustrine-alluvial, alluvial, lacustrine-glacial, subaerial, marsh, eolian and deluvial sedimentary formations are the most common.

The thickness of quaternary deposits ranges from 38.5 to 80 m.

The main engineering-geological features of the described territory are: extremely flat and smooth terrain; wide development of finely-dispersed, silty lacustrine-alluvial sediments, composing interfluvial spaces from the surface. They are highly compressible soils; some of their differences give additional absorbing under soaking; very strong marshiness of the territory; poor development of erosion processes, with the exception of the areas, adjacent to the beds of large rivers [9].

To select a reliable foundation for construction in the examined area, the lithological sections for the wells No. 11 and No. 28 were analyzed (Figs. 2 and 3).

The lithological section of the well No. 11 is represented by the inter-bedding of loams of various consistency and building properties.

DESCRIPTION.

The first layer is represented by semi-solid loams (J_L=0.16, density ρ=2.02 g/cm^3, the modulus of total deformation E=4.9 MPa – highly compressible, adhesion c=0.09 MPa, the angle of internal friction φ=22°). The thickness of the layer is 2.10 m.

The second layer is represented by stiff loams (J_L=0.54, the modulus of total deformation E=4.9 MPa –highly compressible, adhesion c=0.09 MPa). The thickness of the layer is 1.10 m.

The third layer is represented by very softloams

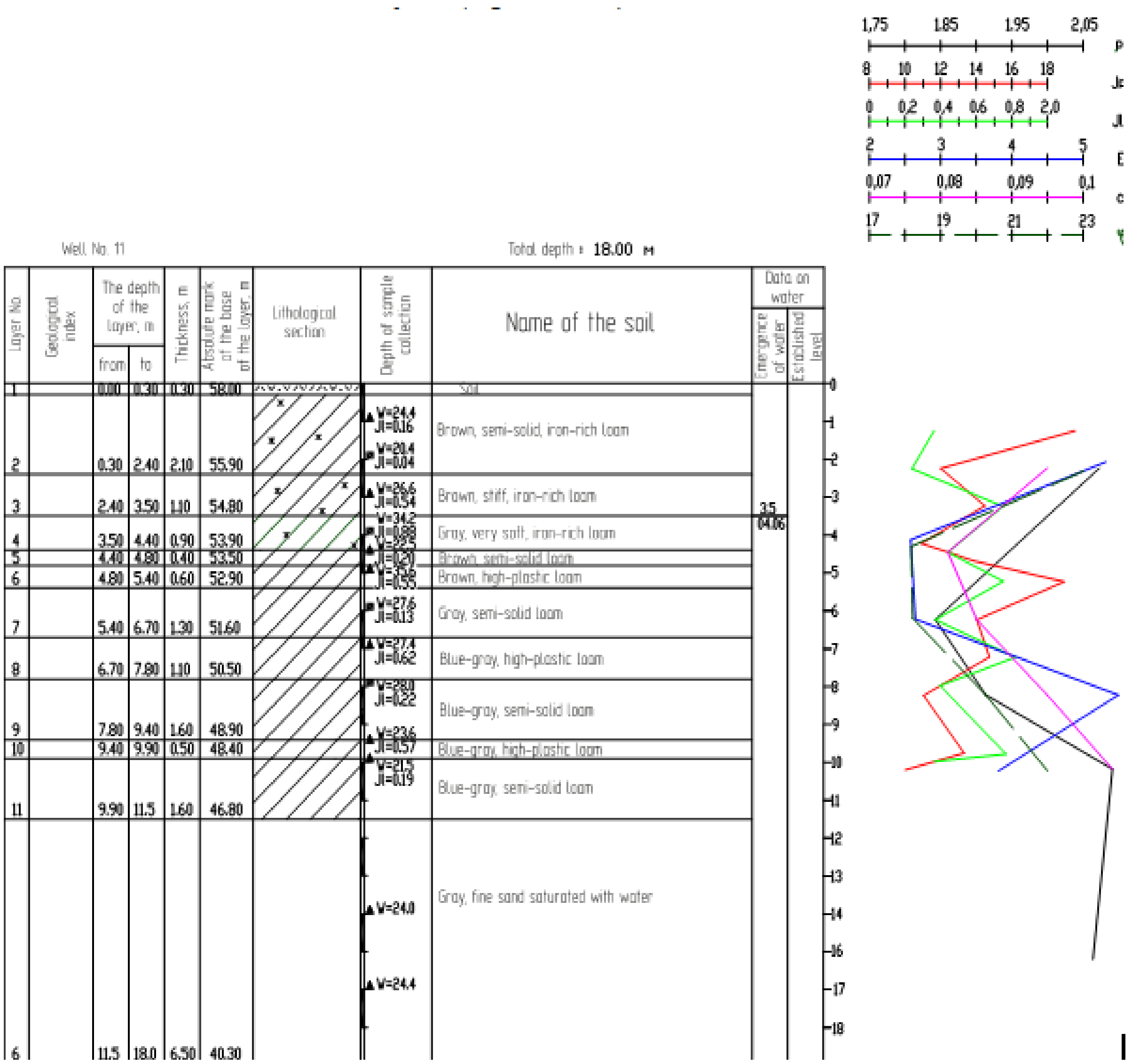

Fig. 2 Graph of changes in the soil properties (well No.11).

(J_L=0.88, the modulus of total deformation E=2.1 MPa –highly compressible, adhesion c=0.075 MPa, the angle of internal friction φ=17°).The thickness of the layer is 0.90 m.

The fourth layer – semi-solid loams. This layer is characterized by: J_L=0.20, the modulus of total deformation E=2.1 MPa – highly compressible, adhesion c=0.075 MPa, the angle of internal friction φ=17°. The thickness of the layer is 0.40 m.

The fifth layer –high-plastic loams (J_L=0.55, the modulus of total deformation E=2.2 MPa – highly compressible, adhesion c=0.08 MPa, the angleof internal friction φ=17°). The thickness of the layer is 0.60 m.

The sixth layer – semi-solid loams (J_L=0.13, density ρ=1.79 g/cm^3, the modulus of total deformation E=2.2 MPa – highly compressible, adhesion c=0.08 MPa, the angleof internal friction φ=17°). The thickness of the layer is 1.30 m.

The seventh layer –high-plastic loams (J_L=0.62, the modulus of total deformation E=2.2 MPa – highly compressible, adhesion c=0.08 MPa, the angle of internal friction φ=17°). The thickness of the layer is 1.10 m.

The eighth layer – semi-solid loams (J_L=0.22, density ρ=1.86 g/cm^3, the modulus of total deformation E=5.0 MPa – highly compressible, adhesion c=0.09 MPa, the angle of internal friction φ=19°). The thickness of the layer is 1.60 m.

The ninth layer –high-plastic loams (J_L=0.57, the modulus of total deformation E=4.9 MPa – highly compressible, adhesion c=0.09 MPa). The thickness of the layer is 0.50 m.

The tenth layer – semi-solid loams (J_L=0.19, density ρ=2.04 g/cm^3, the modulus of total deformation E=3.3 MPa – highly compressible, adhesion c=0.1 MPa, the angle of internal friction φ=21°). The thickness of the layer is 1.60 m.

The eleventh layer is fine sand saturated with water (density ρ=2.01 g/cm^3). The thickness of the layer is 6.50 m.

From the conducted brief layer-by-layer description of the section of the well No. 11, it can be stated that all layers of loams have small thicknesses (from 0.40 m to 2.10 m), these layers are highly compressible, and therefore not one of them can be a reliable foundation. The most acceptable natural foundation is sand. The depth of the bedding is from 11.5 m to 18.0 m. The penetrated thickness of sands saturated with water is 6.50 m. Natural humidity W=24.4% (sampling depth 16 m).

The first layer of the section of the well No. 28 is represented by semi-solid loams (J_L=0.18, density ρ=1.99 g/cm^3, the modulus of total deformation E=1.7 MPa – highly compressible, adhesion c=0.095 MPa, the angle of internal friction φ=17°). The thickness of the layer is 2.10 m.

The second layer – very soft loams (J_L=0.76, adhesion c=0.09 MPa, the angle of internal friction φ=22°). The thickness of the layer is 0.80 m.

The third layer –stiff loams (J_L=0.44, density ρ=1.87 g/cm^3, themodulus of total deformation E=3.1 MPa – highly compressible, adhesion c=0.1 MPa, the angle of internal friction φ=20°). The thickness of the layer is 1.40 m.

The fourth layer –high-plastic loams (J_L=0.57, themodulus of total deformation E=1.7 MPa – highly compressible, adhesion c=0.07 MPa, theangle of internal friction φ=17°). The thickness of the layer is 2.90 m.

The fifth layer – semi-solid loams (J_L=0.08, density ρ=1.95 g/cm^3, the modulus of total deformation E=4.6 MPa – highly compressible, adhesion c=0.09 MPa, the angle of internal friction φ=17°). The thickness of the layer is 2.80 m.

The sixth layer is fine sand saturated with water (density ρ=1.99 g/cm^3). The thickness of the layer is 7.70 m.

The most acceptable natural foundation is sand. The depth of occurrence is from 10.3 m to 18.0 m. The penetrated thickness of sands saturated with water is 7.70 m. Natural humidity W=22.6% (sampling depth 16 m).

The lithological section of this well presents the layers of loams of different consistency and low thickness (layers 1-4).

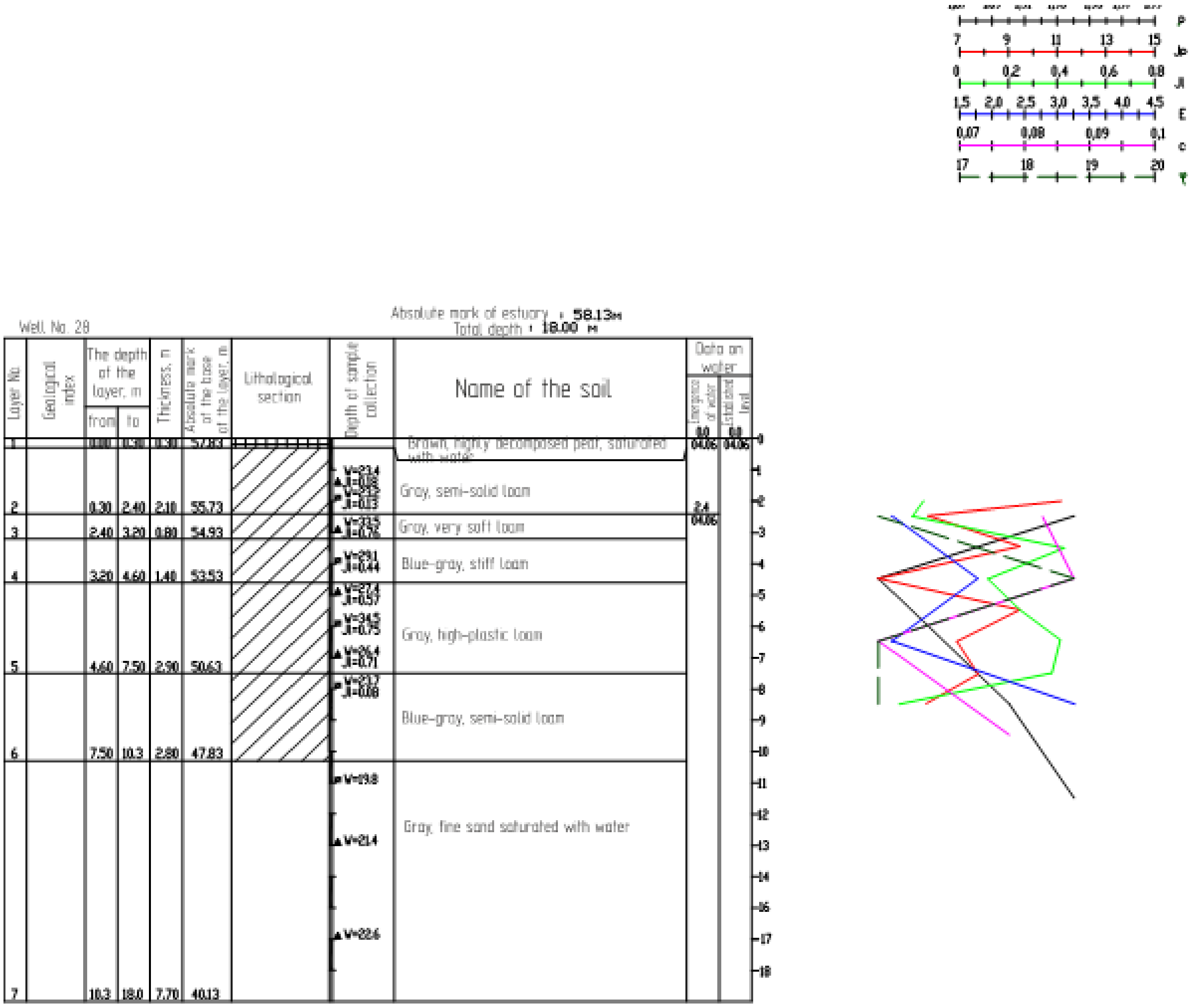

Fig. 3 Graph of changes in the soil properties (well No.28).

The fifth layer – semi-solid loams, with the penetrated thickness of 2.80 m. The base of this layer is fine sands, saturated with water (layer 6), with the penetrated thickness of 7.70 m. Density ρ=1.99 g/cm^3, natural humidity W=22.6%. In this case, the layer 6 may be the natural foundation, since the layer 5 has a small thickness.

Other wells have even less favorable conditions since the layers in the section have a small thickness (inter-bedding of loams of different consistency).

CONCLUSION

From the conducted brief layer-by-layer description of the section of the well No. 11, it can be stated that all layers of loams have small thicknesses (from 0.40 m to 2.10 m), these layers are highly compressible, and therefore not one of them can be a reliable foundation. The most acceptable natural foundation is sand. The depth of occurrence is from 11.5 m to 18.0 m. The penetrated thickness of sands saturated with water is 6.50 m. Natural humidity W=24.4% (sampling depth 16 m).

Thus, when planning the location of the structures of a rotational complex, it is necessary to take into account the presence of a layer of sand, as the most favorable type of a natural foundation for a pile foundation.

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