IJABR

International Journal of Advanced Biotechnology and Research (IJABR)
ISSN 0976-2612, Online ISSN 2278–599X,
Special Issue-1, 2019, pp321-325
http://www.bipublication.com

Research Article

Soil Conditions for the Construction of a Rotational Complex of the West Salym Field

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ABSTRACT.
The article presents the results of the study of the soil conditions for the construction of a rotational complex in the territory of the West Salym field of the Khanty-Mansi Autonomous District of the Tyumen Region of the Russian Federation. Three stratigraphic-genetic complexes, represented by the soil-vegetation layer, modern lacustrine-boggy sediments, and mid-quaternary lake-alluvial sediments, were identified on the engineering-geological sections up to a depth of 15 meters. The landscape of the site is characterized by such exogenous processes as: waterlogging, the presence of seasonally freezing and thawing soils. According to the results of drilling and the laboratory studies of the properties of soils, the graphs of changes in the manifestation of such properties as density, adhesion, the angle of internal friction, the modulus of total deformation and the density of soilswerecompiled. It is shown that the soil conditions of the site are unfavorable due to low strength and strong deformability of soils.

Keywords: Modulus of total soil deformation, Adhesion of soil particles, Physical and mechanical properties of soils, Engineering-geological element, Stratigraphic-genetic complex.

INTRODUCTION

In the north of Western Siberia, performing engineering-geological surveys is complicated by the extensive development of waterlogging processes, new formations of permafrost, heaving, thermokarst, etc. The inclusion of the analysis of the soil conditions in the complex of engineering-geological studies makes it possible to visually assess the properties of soils by depth and the choice of the type of natural base, and then to make the right design decisions when choosing the type of the foundation.

METHODS

The soil conditions for the construction of a rotational complex of the West Salym field were analyzed on the basis of the drilling data from 24 exploratory wells. In the process of conducting the surveys and analyzing the data, 8 engineering-geological elements were selected, represented by loamy and sandy loam soils of various consistencies, as well as peat and the soil-vegetation layer. The hydrogeological and geomorphological conditions wereexamined. The monoliths and the samples of a disturbed structurewere transferred to the laboratory, where the indicators of physical and physical and mechanical properties of soils were determined.

RESULTS

The behavior was analyzed in accordance with the manifestation of such indicators of the soil properties as density, the angle of internal friction, adhesion andthe modulus of total deformation, characterizing the soil conditions of the site[1, 2]. The results of the analysis showed that the conditions for the construction of a rotational complex are unfavorable due to low strength and strong deformability of soils.

DISCUSSION

The examined site is located in the north of the West Salym field, in the NefteyuganskyDistrict of the Tyumen Region of Russia.

The territory of the examined site is located within the fourth terrace above the flood-plain, composed of mid-quaternary lake-alluvial sediments.

The absolute marks of the surface of the work site vary from 74.51 m (in the north) to 85.10 m (in the south). The general slope of the territory from the south to the north is 8°. The terrain is flat with separate elevations.

A characteristic feature of the site is the waterlogging of the northern part of the site, confined to degradation in the terrain. Bogs of pine-dwarf shrub-sphagnum microlandscape are characterized by dense peat of type I with the resistance of peat to heave over 0.15 kg/cm2. Waterlogging is common in the north of the examined site. Flat, as well as hummock-ridge oligotrophic and oligotrophic-mesotrophic afforested bogs, are typical. In addition to climatic factors (excessive atmospheric moistening for local temperature conditions), the development of the waterlogging processwithin the examined territory is affected by insignificant terrain slopes, weak infiltration properties of the underlying rocks, which worsen the drainage conditions.

The geological section of the upper part of the quaternary sediments to a depth of 15.0 m is composed of mid-quaternary lake-alluvial sediments, covered by modern lacustrine-boggy sediments in the north and the soil-vegetation layer.

Three stratigraphic-genetic complexes were identified on the sections of the data from the drilled wells:

- solQIV – soil-vegetationlayer,
- lbQIV – modern lacustrine-boggy sediments,
- laQII –mid-quaternary lake-alluvial sediments.

According to the classification of GOST 25100-2011 [3], the sediments of the site belong to the disperse class, the cohesive subclass, sedimentary and eluvial types. The sedimentary type, in turn, is divided into the lake-alluvial and the lacustrine-boggy subtypes. By type, mineral soils are lake-alluvial, and organic soils are lacustrine-boggy sediments. The subspecies of mineral soils are clay soils, and the subspecies of organic soils are peat. Eluvial sediments include the physical and chemical subtype, the type is organic and mineral soils, the subtype is soil.

Within the site, the boggy waters are exposed at a depth of 0.1 m, the subsoil waters are exposed at different depths, this is due to the heterogeneity of the lithological composition. The subsoil waters arefree-flowing or have little local pressure. The well flow rates do not exceed hundredths of a liter per second. The horizon is powered by atmospheric precipitation and melt water. Unloading is in the lowering of the terrain and the bog.

Soil Conditions for the Construction of aRotational Complex. The physical and mechanical properties of soils are determined by their genesis, structure, texture, formation, and processes that occur in them[4-7].

The study of the physical and mechanical properties of soils was conducted by visual, field and laboratory methods. The results are shown in Table 1.The authors compiled the graphs that show how the properties of soils change with a depth of three wells: No. 17, No. 18 and No. 19.In the well No. 17, the sediments are represented by peat saturated with water up to 0.8 m.

The loams lie below. Very soft loams are up to 2.4 m, from 2.4 m there is high-plastic loam up to 15 m. But in the depth interval of 2.8-4.8 m, an increase in the magnitude of the modulus of deformation and strength is observed, and the value of the angle of internal friction decreases.

In the well No. 18, the sediments are represented by tough clay up to 1.8 m. In them, the physical indicators of the soils are conditionally homogeneous. Since in accordance with the graph, it is impossible to determine the patterns of changes in the properties, this requires additional research. Tough clays are underlain by high-plastic loams up to 3.6 m. A gradual increase is observed in them in the modulus of deformation up to 3 MPa, a decrease in the adhesion and the angle of internal friction. In the underlying very soft loams – up to 5.2 m, the modulus of deformation is reduced to 2.5 MPa, the angle of internal friction is slightly increased, and the strength continues to decrease. Adhesion decreases also in stiff loam, deposited at the depth of up to 7 m. The angle of internal friction is 19°.

Table 1: Physical and mechanical properties of soils

Ser. No.	Well No.	Depth of sample collection	Humidity	Plasticity number	Index of liquidity	Density			Coef. of porosity	Angle of internal friction	Adhesion	Modulus of deformation	Characteristics of the soil
						soil particles	soil	soil skeleton					
		[m]	[%]	[%]	[un. fr.]	[g/cm^3]			[un. fr.]	[deg.]	[kPa]	[MPa]	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	17	1.6	30.7	16.6	0.79	2.72	1.90	1.45	0.88	12	7.00	1.90	very soft loam
2	17	2.8	32.6	16.0	0.62	2.68	1.85	1.40	0.91	24	7.00	1.76	high-plastic loam
3	17	4.7	34.8	13.2	0.55	2.65	1.83	1.36	0.95	24	16.00	3.06	high-plastic loam
4	17	5.8	36.1	11.5	0.71	2.63	1.73	1.27	1.07	20	14.00	1.69	high-plastic loam
5	17	8.0	33.4	15.3	0.74	2.69							high-plastic loam
6	17	10.5	26.8	10.1	0.73	2.70							high-plastic loam
7	17	12.5	28.8	14.1	0.75	2.71							high-plastic loam
8	17	14.5	30.4	15.6	0.65	2.71							high-plastic loam
9	18	1.3	30.7	18.9	0.38	2.74	1.75	1.34	1.04	18	37.00	0.98	tough clay
10	18	2.6	30.3	15.2	0.54	2.72	1.94	1.49	0.83	11	27.00	3.00	high-plastic loam
11	18	4.7	34.0	14.8	0.78	2.67	1.88	1.40	0.91	15	22.00	2.50	very soft loam
12	18	6.0	28.8	12.7	0.46	2.67	1.90	1.48	0.80	19	21.00	3.19	stiff loam
13	18	7.8	27.1	9.6	0.51	2.68	1.96	1.54	0.74	16	28.00	3.95	high-plastic loam
14	18	10.0	24.0	7.3	0.62								high-plastic loam
15	18	12.5	30.3	9.2	0.93								very soft loam
16	18	15.0	30.1	9.2	0.74								high-plastic loam
17	19	1.8	22.1	10.5	0.10	2.72	1.84	1.51	0.80			2.03	semi-solid loam
18	19	3.0	26.6	15.7	0.33	2.71	1.93	1.52	0.78	5	50.00	2.73	stiff loam
19	19	4.8	32.3	17.1	0.40	2.68	1.84	1.39	0.93	6	29.00	1.92	tough clay
20	19	6.0	31.8	12.8	0.67	2.67	1.82	1.38	0.93	21	16.00	2.00	high-plastic loam
21	19	7.5	32.0	13.9	0.52	2.67	1.82	1.38	0.93	16	33.00		high-plastic loam
22	19	9.5	19.9	3.9	0.64								soft sandy loam
23	19	12.0	26.0	7.5	0.65								high-plastic loam
24	19	14.0	26.3	8.5	0.51							-	high-plastic loam

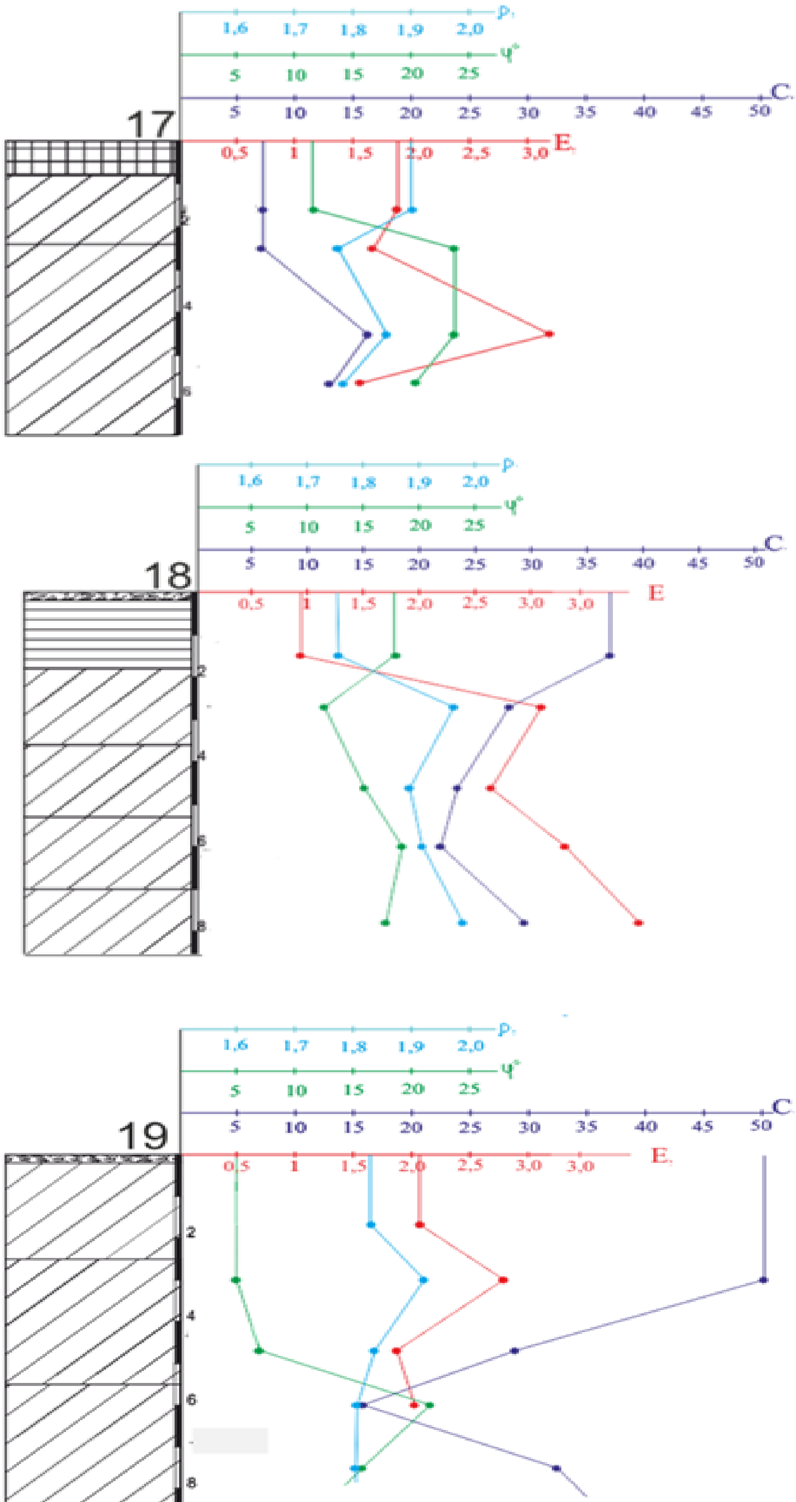

Fig. 1 Graphs of changes in the properties of soils with a depth of wells No. 17, 18, 19. Units of measurement of density (ρ) – g/cm^3, angle of internal friction φ – degrees, adhesion (C) – kPa, modulus of total deformation (E) – MPa.

A sharp increase in strength (up to 28 kPa) and an increase in the value of the modulus of deformation, as well as a slight decrease in the angle of internal friction, are observed in the underlying high-plastic loams, deposited at the depth of up to 11.5 m. Below to a depth of 13.7 m, very soft loam and high-plastic loam are deposited up to 15 m. The angle of internal friction, adhesion, and the modulus of deformation was not determined for them.

In the well No. 19, sediments up to a depth of 2.5 m are composed of semi-solid loams – all the indicators in them are approximately the same, according to the graph it is impossible to determine the patterns of changes in the properties of the soil, therefore additional studies are required. Below there is stiff loam up to 5.5 m. An increase in the modulus of deformation is observed in them; it is equal to 2.8 MPa. Adhesion decreases and reaches its minimum (16 kPa) in high-plastic loam, deposited at the depth of up to 8.7 m. A decrease in the angle of internal friction is also observed in them. The largest angle of internal friction is in high plastic loam (22°), lying down to a depth of 8.7 m. Below, there is soft sandy loam up to 11.3 m and high-plastic loam up to 15 m. The angle of internal friction, adhesion and the modulus of deformation were not determined for them.

The graphs show that the modulus of deformation (E, MPa) turned out to be less than 5 MPa for all soils, regardless of their consistency, that is, all the soils of the site, according to the classification of GOST 25100-2011 [3], are quite strongly deformable. The main process that will develop within the site is compaction. The graphs show a simultaneous increase or decrease in the modulus of deformation and density.

The studied soils have the following indicators of strength – adhesion (C):

- tough clays 29-33 kPa (low strength),
- semi-solid loams – not determined,
- stiff loams 21-50 kPa (low to medium strength),
- high-plastic loams 7-33 kPa (extremely low and low strength),
- very soft loam 22-7 kPa (extremely low and low strength),
- soft sandy loams – not determined.

CONCLUSION

Thus, the soils composing the site have extremely low, low and medium strength. Comparing the adhesion and the density of the soil in the graphs, it can be seen that with increasing density, the adhesion also increases [8].

The maximum value of the angle of internal friction is observed in high-plastic loam amounting to 24°, the smallest is in stiff loams,amounting to 5°. As the consistency increases, the angle of internal friction decreases, while the consistency decreases, the angle of internal friction increases.

Thus, having analyzed the graphs of changes in the properties of soils with depth, it can be concluded that the soils are unfavorable for construction and it is required to study them in more detail to a greater depth. When solving design issues at the work site, it is necessary to provide for the strengthening of the foundation.

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