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Study Of Negative Friction Forces Under Laboratory Conditions

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ABSTRACT

The article presents the conditions for the study of negative friction forces in the laboratory, experimental setup, measuring equipment and soil characteristics, experiments and analysis of the results.

KEYWORDS

Negative friction forces, piles, tensile piles, experimental patch, sand, roughness, displacement, specific magnitude of friction forces, surcharge.

INTRODUCTION

The strategy of actions in five priority directions of development of the Republic of Uzbekistan in 2017-2021 was the most important program document that determined the priority directions of state policy for the medium term. It states that within two months, develop and introduce a program for the innovative development of the construction sector, bearing in mind measures to stimulate the entry of domestic design and contractors into foreign markets, a complete revision of urban planning norms and rules, taking into account modern international standards, the active introduction of energy-saving technologies.

When erecting residential and industrial buildings and structures in weak, highly compressible, subsiding and thawing soils, pile foundations are increasingly being arranged. When using pile foundations in the latter case, a number of problems arise associated with their immersion in the ground and further work. For piles, it is necessary to make a bearing capacity calculation, in which it is necessary to take into account the effect of negative friction forces arising during settlement near the pile soil. However, the existing methods of determination do not take into account a number of factors affecting the magnitude of the forces of negative friction.

THE MAIN FINDINGS AND RESULTS

The abundance of acting factors complicates the determination of reliable values of the specific and total forces of negative friction, and if the consideration of factors related to the geometric dimensions of the piles and their configuration, as well as the magnitude of the load on piles and soil, does not present any particular difficulties, then taking into account factors depending on the physical and mechanical properties of the soil and the characteristics of its interaction at the contact with the lateral surface of the pile, creates the greatest difficulties and brings with it a number of problems.

When determining the forces of negative friction, the following soil characteristics are usually used: the specific gravity of the soil γ, the angle of internal friction of the soil φ, the angle of its shear along the material of the pile φ_{gm}, the coefficient of the lateral pressure of the soil at rest ε_0, the value of the threshold relative displacement δ_0, which is called in the further shear displacement $\bar{S}$.

Obviously, the best way to determine the listed characteristics of soils is an experimental one, performed with soils of identical density, grain size composition, moisture content, and the like, while observing the adequacy of the stress state in the experimental soil sample and in the massif after immersing the pile into it.

In laboratory conditions, the patterns of the action of negative friction forces in the spectrum of factors affecting the magnitude of these forces were revealed.

1. Experimental setup, measuring equipment and soil characteristics.

The experimental setup is a cylindrical chute with a diameter of 0.5 m, in the center of which a model tenso-metric pile is placed, around which sand with the required density is laid (Fig. 1). The vertical load on the sand is created by the fluid pressure in the annular rubber cylinder, which reproduces the flexible load from the overlying soil layers. The walls of the tray from the inside were lined with two, and in some experiments with four layers of polyethylene film, lubricated with grease, which made it possible to significantly reduce the friction forces arising along the wall of the tray when the soil was moved under pressure in the upper cylinder. To fix the pressure coming to the bottom of the tray, a lower cylinder was used, similar in design to the upper one. Both cylinders were filled with water; the necessary pressure was created using a hydraulic accumulator. In some experiments, the lower cylinder was replaced by a rigid bottom, which made it possible, on the one hand, to avoid soil movements caused by the deformation of the lower cylinder, and on the other hand, to provide a fixed movement of the lower bottom by the required amount.

When sand was laid in a tray and its pressure was applied from the upper cylinder, the heel of the pile rested on the lower screw device fixed on the base plate. By adjusting the screw device accordingly, it is possible to release the pile from the stop, or move it upwards during the pull-out test, which can also be performed autonomously with an upper jack.

In the experiments, three model sectional strain gauge piles of two types with an outer diameter of 60 mm were used. The sections of the pile models of the first type are assembled with a gap between them and are joined by means of cylindrical strain gauges.

Steel models ST-I with a smooth outer surface (1U roughness class) and ST -2 with increased roughness obtained by machining (thread height 0.5 mm, pitch I mm) were made of this type. The second type differs from the first in that the connection of the sections is carried out in it by means of strain gauge inserts in the form of coils screwed into the connected sections, which allows the use of piles of this type for tensile effects. This type was used to manufacture the ST -3 duralumin pile with increased roughness, similar to the ST -2.

The maximum useful length of piles in the sand (between the bottom of the upper cylinder and the top of the lower one) is 0.8 m. The efforts in the piles were recorded at four levels, that is, at the junctions of the sections where the strain gauges were located.

The strain gauges were made of D16t duralumin with a height of 30 mm and an outer diameter of 20 mm.

To measure the pressure in the cylinders, exemplary manometers with an accuracy class of 0.6 were used, which made it possible to measure pressure with an accuracy of 0.002 MPa. The load on the pile was created by a screw jack, and its fixation was carried out according to the indications of a model CDM-3-1 dynamometer. The readings of the strain gauges were registered either by CTE-3 with an accuracy of 1x10-5 units, or IDC-1 with an accuracy of 1x10-6 units. To control the magnitude of the total forces of negative friction, a CDM-3-1 mechanical dynamometer was used, which was installed between the lower screw device fixed on the base plate and the fifth pile.

The movements of the pile were recorded at two levels (in the head and heel) using hour indicators with an accuracy of 0.01 mm. The measurement of the sediment of the roof and bottom of the laid sand layer was carried out at three points in the plan using marks, the ends of which were brought out beyond the side surface of the tray. In addition, the sediment of the sand surface was monitored by changing the liquid level in the measuring tube of the accumulator with an accuracy of I mm, which ensured an accuracy of measuring the sediment of 0.3 mm.

In all experiments, air-dry medium-grained sand (Table 1) of average density (γ = 16.5 kN / M3, e = 0.605) with a uniformity coefficient Kn = 2 was used. The sand was poured into the tray layer by layer with subsequent compaction to required density.

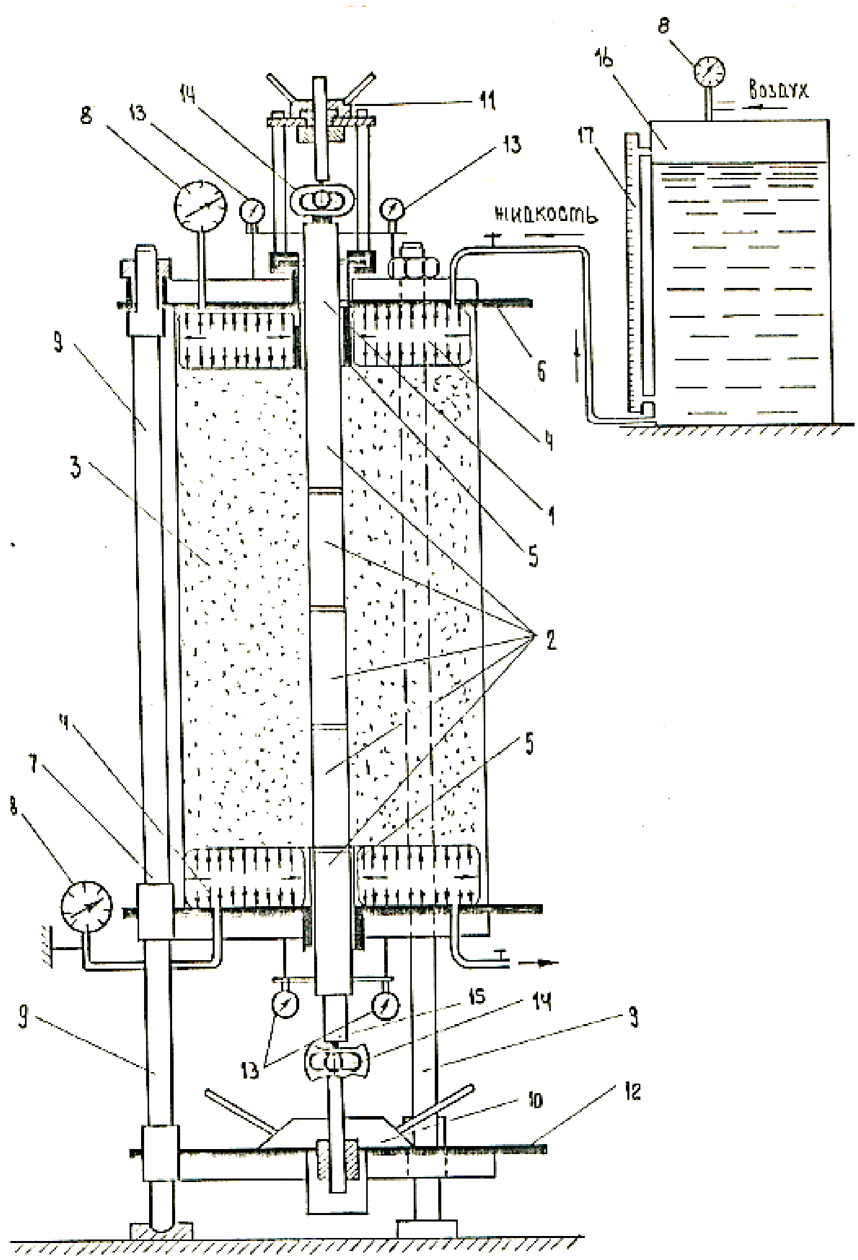

Fig. 1. Experimental tray layout:

1 - strain gauge; 2 - tensosection; 3 - sand; 4 - rubber container;

5 - limiter; 6 - cover; 7 - bottom; 8 - manometers; 9 - racks; 10.11 - upper and lower screw device; 12 - thrust plate; 13 - indicators; 14 - dynamometer; 15 - adapter; 16 - hydraulic accumulator; 17 - measuring tube

Table 1

Content in% of particles size, mm					
5	5-2	2-1	1-0,5	0,5-0,25	0,25
0,31	0,91	7,84	15,84	55,32	19,8

Conducting Experiments

In the preparation of each experiment, the model pile was supported either on the lower dynamometer or on an adapter connected to the lower screw device, and its head was fixed in a conductor for centering along the axis of the tray. Next, sand with the required density was laid in layers, that is, the experiments were carried out with models of piles, the immersion of which into the ground does not cause filling normal stresses to their lateral surfaces. After laying the sand in the tray, the power unit was installed, then the measuring equipment was installed, after which the experiment began.

Eight experiments were carried out on the experimental setup, of which most were devoted to the study of the emergence and stabilization of negative friction forces, as well as their decrease and disappearance. The experiments were carried out with three models of piles (experiments 1-3 with ST-I, experiments 4-6 with ST -2, experiments 7 and 8 with ST -3), and in experiments with ST -I and ST -2 sand poured onto the lower cylinder, and in experiments with the TS-3, the lower cylinder was replaced by a hard bottom. These experiments were carried out in three stages. At the first stage, the sand was loaded with the pressure of the upper cylinder in steps of 0.02 MPa. The holding time of each stage was I h, which ensured the stabilization of friction forces during the movement of the soil caused by the surcharge. After bringing the surcharge to q = 0.1 MPa, the second stage began, which consisted in the movement of the soil relative to the fixed pile, carried out by reducing the volume of liquid in the lower cylinder or lowering the rigid bottom by the required value sufficient to fix a constant value of the total force negative friction Nn. At the third stage, the pile was freed from the stop, and it moved down (free or forced) until Nn = 0.

Some experiments (I, 3, 4) were continued for studies related to the re-emergence of negative friction forces and their disappearance. In this regard, in the above experiments, the displacements of the bottom of the sand layer and the pile, as well as the effect of an external load causing the downward displacement, were varied in different sequences.

RESULTS OF EXPERIMENTS AND THEIR ANALYSIS

The emergence of forces of negative friction. In fig. 2, fig. 3. as an example, the results of separate experiments with each model are given. The values of the total forces of negative friction Nn with an increase in the surcharge q are given in Table 2, from which it can be seen that in all eight experiments an increase in Nn is observed with an increase in pressure. However, the increase in the values of Nn (q) is not proportional to the increase in surcharge q, which is explained by the dependence of the specific friction forces also on the magnitude of soil displacements relative to the pile. The latter are different in the length of the pile: for example, at the level of the sand roof (Table 3), they, as a rule, exceed the threshold value of the shear displacement δ_0= 1–2 mm required to realize the maximum forces of specific friction, and at its level on the sole, they are either zero (in experiments with ST-3), or they are 1–2 mm (in experiments with ST-I and ST-2 at q = 0.1 MPa). This circumstance, as well as the fact that the gradient of sand displacements with increasing q dies out, and leads to the fact that a fivefold increase in q leads to an increase in the values of Nn by only 2.5 - 3.5 times.

In connection with this circumstance, the question arises - are the obtained values of Nn (q) maximum? The answer to this question was given by tests carried out at the second stage, when the bottom of the sand layer was displaced at q = 0.1 MPa. The values of Nn (δ) are given in Table 4, where the sign is determined from the condition that the pile remained motionless, and the bottom of the soil layer moved down. It can be seen from these experiments that, firstly, when the bottom of the layer is displaced, the values of Nn somewhat increase, and secondly, after reaching the maximum Nn (δ), the values of the total negative friction forces for models of piles with a smooth surface remain constant, and for the mode Layers with a rough surface, they slightly decrease, which is due to the combination of the increased roughness of the surface along which shear occurs, with a certain density of sand.

Table 2

No. of experiments	Model designation	Nn (q) value at pressure q in MPa				
		0,02	0,04	0,06	0,08	0,10
1	ST-1	1,10	1,55	2,07	-	2,56
2		1,28	1,57	1,90	2,34	2,64
3		0,83	1,18	1,68	2,0	2,48
4	ST -2	1,28	1,90	2,54	3,04	3,42
5		1,20	1,82	2,38	2,78	3,22
6		1,46	1,98	2,78	3,06	3,26
7	ST -3	1,13	2,07	2,86	3,66	4,18
8		1,36	2,07	2,75	3,44	3,84

Table 3

No. of experiment s	Model designation	Ss value, q mm, at pressure q in MPa				
		0,02	0,04	0,06	0,08	0,10
1	ST -1	2,55	4,53	5,38	-	7,35
2		2,54	4,66	5,66	7,08	8,49

3		2,54	4,53	5,66	6,79	7,92
4	ST -2	2,55	4,81	6,23	7,36	8,77
5		3,40	5,94	9,06	10,0	11,32
6		3,40	5,10	6,50	7,64	9,06
7	ST -3	3,62	4,81	5,94	6,79	7,64
8		2,26	3,69	4,81	5,38	6,23

$S_{s,q}$ – moving sand at the level of its roof

Reduction and disappearance of negative friction forces. As the pile moves down, the N_n values decrease (Fig. 4). The minimum displacements of piles $\delta_{p,min}$ required to completely eliminate the negative friction forces acting on the pile are given in Table 5. When displacements $\delta_p > \delta_{p,min}$, positive friction forces arise on the lateral surface of the pile.

Table 4

No. of experiments	Model designation	Nn (δ) kN value, with δ in mm						
		0	-0,5	-1	-1,5	-2	-2,5	-3
1	ST-1	2,56	2,85	2,98	3,08	3,13	3,11	3,09
2		2,64	2,64	2,64	2,74	2,77	2,80	2,86
3		2,48	2,52	2,56	2,48	2,58	2,54	-
4	ST -2	3,42	-	3,36	3,00	3,04	–	-
5		3,22	3,36	3,44	3,36	3,44	3,44	-
6		3,26	3,70	3,56	-	3,16	3,00	-
7	ST -3	4,18	4,14	4,30	4,48	4,30	-	4,18
8		3,84	3,95	4,00	3,96	3,88	3,81	3,73

Table 5

Values $\delta_{p,min}$, mm, in experiments							
1	2	3	4	5	6	7	8
ST-1			ST-2			ST-3	
0,70	0,51	0,45	0,49	0,49	0,42	0,44	0,46

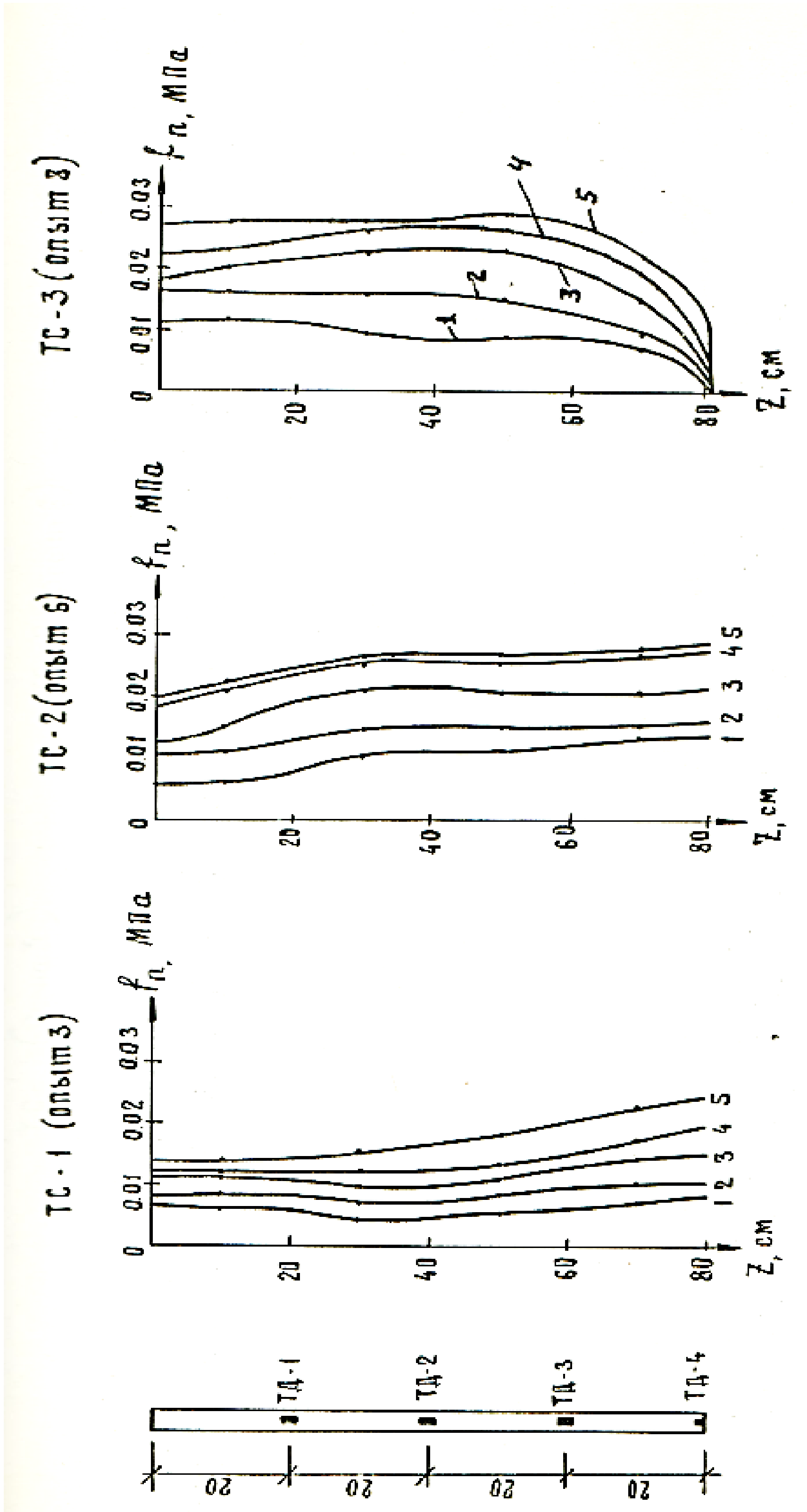

Fig. 2. Plots of specific forces of negative friction fn at different Values under load *q*:
I, 2, 3, 4, 5 - respectively at q = 0.02; 0.04; 0.06; 0.08 MPa;
SG - strain gauges

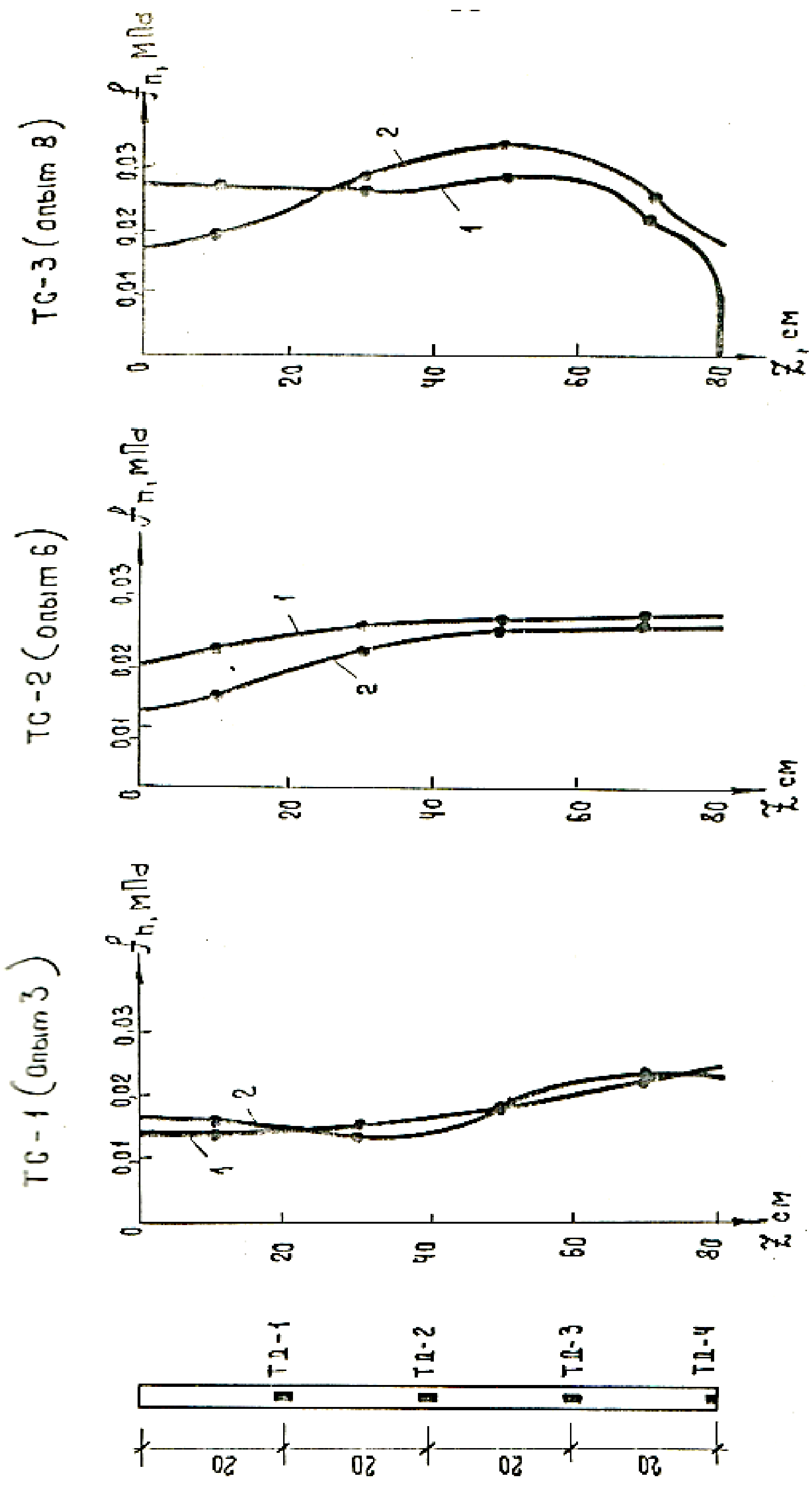

Fig. 3. Diagrams of the specific forces of negative friction fn during soil compaction and bottom displacement:

1-at q = 0.1 MPa; 2 - when moving the bottom δ = 2 mm.

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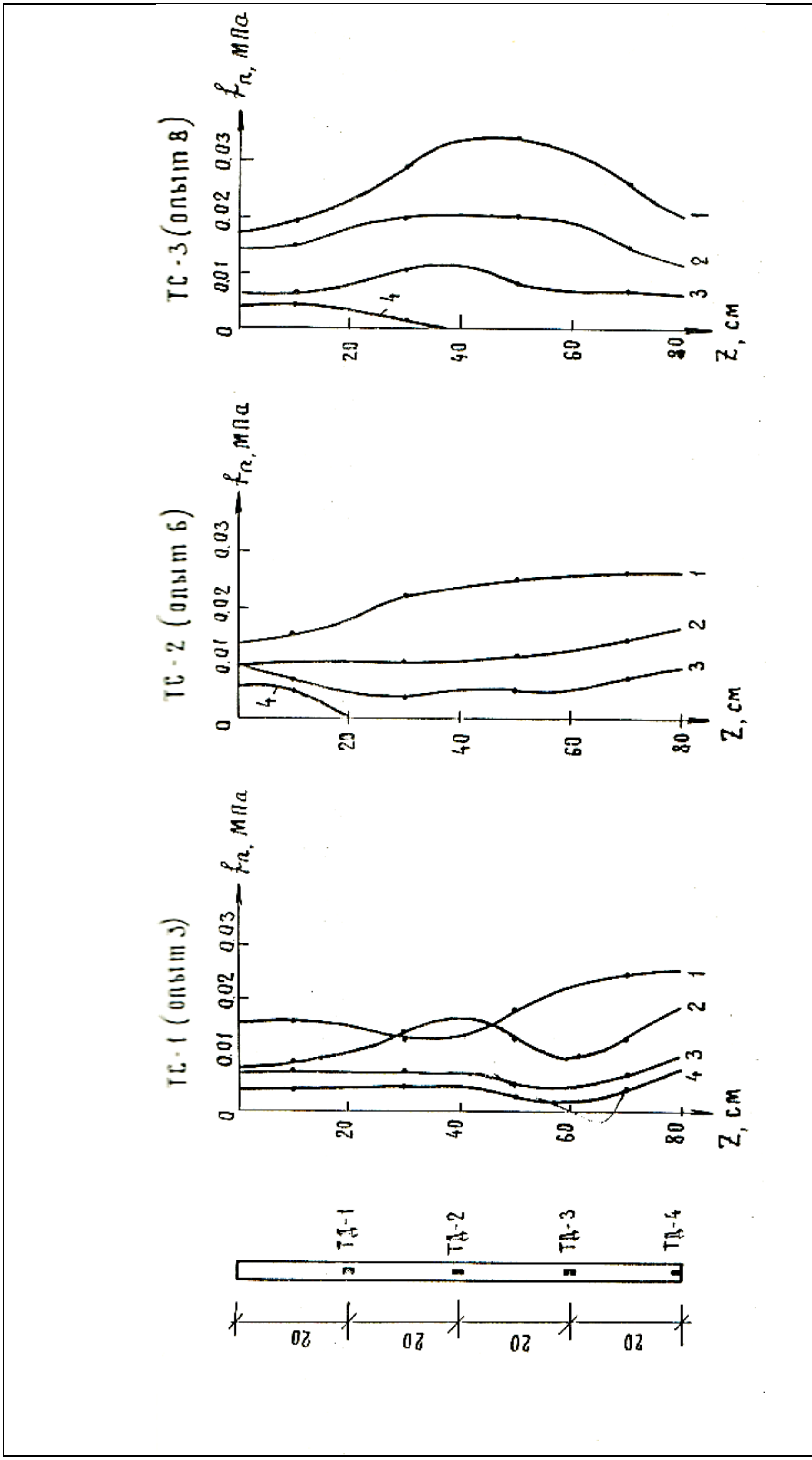

Fig. 4. diagrams of specific forces of negative friction f_n when moving the pile δ_p 1,2,3,4 - values of f_n, respectively, at δ_p=0; 0,2; 0,55; and 0.45mm...

From the experiments performed, it can also be concluded that the state of the lateral surface of the pile affects *Nn*. Comparison of the average values of *Nn (q)* acting on rough (ST-2) and smooth (ST-I) steel piles at q = 0.1 MPa shows that the effect of the surface state on the forces of negative friction is estimated at 25-30%.

CONCLUSION

1. The impact of negative friction forces on the pile is manifested when moving near the pile soil, while the reason for the movement is not decisive in determining the magnitude of these forces, which depends on the following factors - the angle of friction of the soil over the pile material, acting stress normal to the shear plane, the value of soil displacement relative to the pile. The maximum forces of negative friction are realized after the relative displacement exceeds a certain threshold valueδ_0, which for sands is, as a rule, 1-2 mm.
2. A decrease in the forces of negative friction is caused, with other unchanged conditions, by the displacement of the piles; for the complete elimination of the forces of negative friction, it is sufficient that the pile is displaced relative to the ground by 0.5-1 mm, which is approximately half the value of the threshold displacement δ_0.

REFERENCES

1. Bakhromov M.M. (1984) Study of the negative friction of thawing soils in the field / Leningrad Zonal Research Institute of Experimental Design. – Leningrad. – p. 25. - Dep. in VNIIIS, 27.03.84, J * 4931.
2. Bakhromov M.M. To the question of determining the friction forces along the lateral surface of piles in sandy soils // Found ations of residential and public buildings erected in the northern and north-eastern regions of the country: Sat. scientific. tr. / Leningrad Zonal Research Institute of Experimental Design. – Leningrad. – pp. 100-113.
3. Bakhromov M. M. Rakhmonov E.KH. Otakulov B.A. Determination of negative friction forces during thawing of near-pile soil. European science, 2019 Februaru No. 1 (43) Imperial College London. – pp. 22-25.
4. Bakhromov M. M. Rakhmonov U. J. Otaboev A. (2019) Impact of negative friction forces on the pile during soil subsidence. Scientific-Methodological Journal. Problems of modern science and education. No. 12 (145). Part 2.31-42 p.
5. Bakhromov M.M., Rakhmonov U. J. (2019) Regularities of the impact of negative friction forces on the lateral surface of piles. Scientific-Methodical Journal. Problems of modern science and education. No. 12 (145). Part 2. – pp. 69-73.
6. Bakhromov M.M. Rakhmonov U.J. "Problems of construction on subsiding loess and soft soils and their solution". Scientific And Technical Journal "Inter-science".
7. Building regulations 2.02.01-83. Foundations of buildings and structures. – Moscow. 1985.41 p.
8. Building regulations 11 2.02.03-85. Pile foundations. – Moscow.1986 .-- 44 p.
9. КМК 2.02.01 - 98. Construction norms and rules "Foundations of buildings and structures". State Committee of Architecture Construction of the Republic of Uzbekistan 1998.