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Method of static testing of a bored pile for pressing and pulling loads (test trials)

Baku - 2022

1. Introduction

Static testing of bored piles for indenting and pulling loads is a set of measures carried out to check the compliance of the bearing capacity of piles with the design loads specified in the design of the engineering structure under construction. The essence of the test procedure is that the hydraulic jack applies loads to the piles, gradually increasing the applied load in stages. The data observed at each stage according to the readings of the instruments are recorded, and on the basis of these static indicators, a conclusion is made about the compliance with the project of the accepted cross-section of the pile and the depth of its driving. Piles are tested in accordance with the requirements of GOST 5686-2012.

2. Information about the tested pile

Area where testing is being carried out:	Pile No. 74 on the A2 pillar of the bridge under construction across the Velveli-Chay River on the Baku-State Border of the Russian Federation highway
Mark of the tested pile according to the project:	3540-ST001I-PL022A (No 74)
Mark of the anchor piles according to the project:	3540-ST001I-PL015A(No 73) / 3540-ST001I-PL030A (No 75)
Tested pile diameter:	1200 mm
Driving depth of the tested pile:	18 m
Maximum test load:	375 t
Design (working test) load:	250 t
Maximum load for each one anchor pile:	375/2 = 187,5 t
Anchor pile diameter:	1200 mm
Test start date:	29.04.2022
Test end date:	30.04.2022

3. Equipment and devices.

The following equipment and devices are used to test the pile with static indentation and static tensile loads:

1. Special automatic hydraulic pump station - 1 set
2. Hydraulic jack module to transfer the load to the pile - 1 set
3. Test steel cap, which is put on the top of the pile (the diameter corresponds to the diameter of the pile) - 1 set

4. High pressure hoses (high pressure hoses) with couplings and fittings - 3 sets
5. Loading platform for transferring test loads to the pile, consisting of steel beams connected to anchor piles - 1 set
6. Caliper (for measuring deformations) - 2 sets
7. Pressure gauge - 1 set
8. Steel pipes and steel reinforcing bars - 2 sets

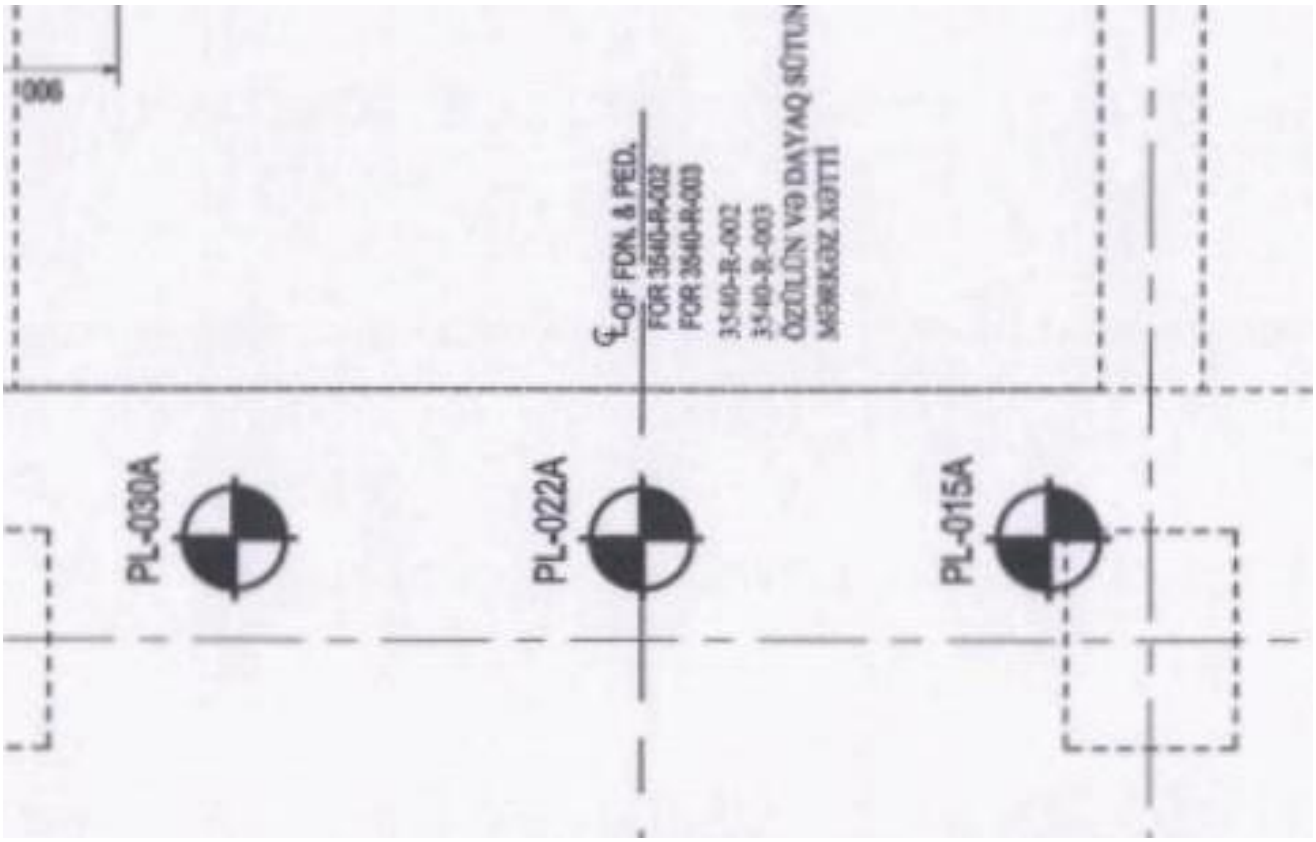


Figure 1. Location of the tested pile and anchor piles for testing for static indentation and static pullout loads (detail project fragment)

4. Test facility for static testing of a bored pile for indentation and pull-out loads.

The main elements of the test facility are anchor piles, load platform and hydraulic jack. The hydraulic jack generates static pressure (pulling force). The tested pile is attached to the anchor piles located on both sides of the tested pile by means of a steel traction system (loading platform) (see figures 2, 3).

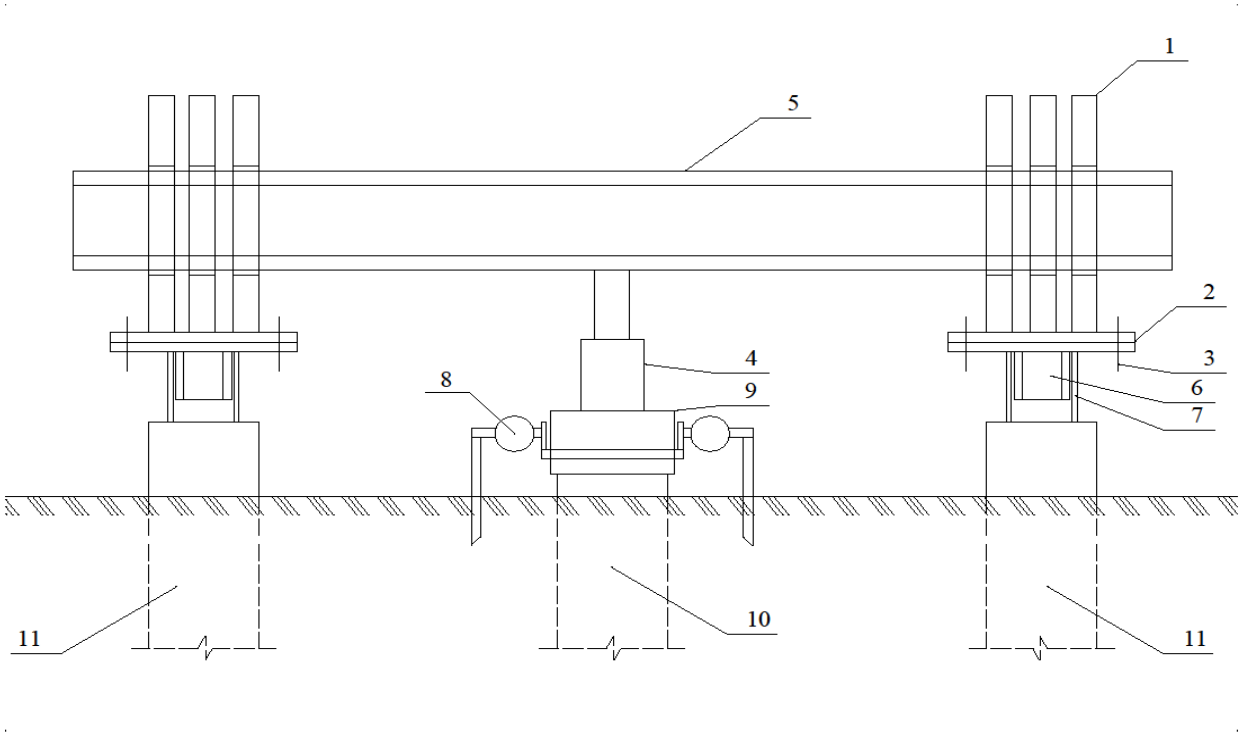


Figure 2. Test facility scheme for testing the pile with static indentation load

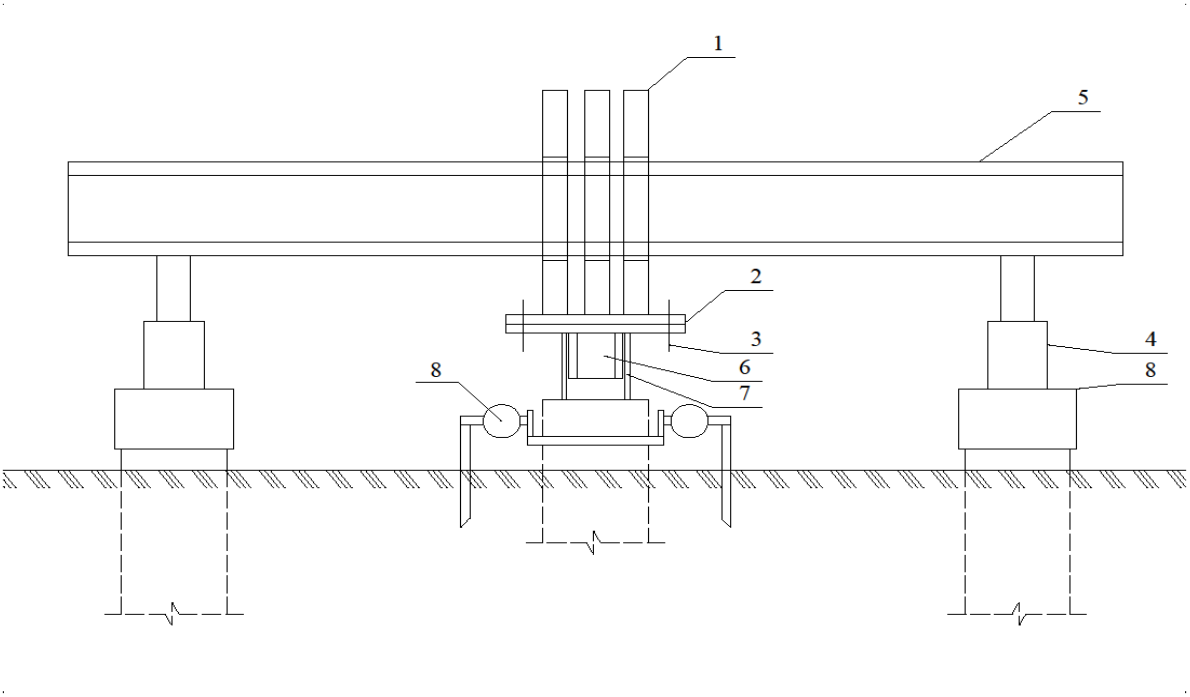


Figure 3. Test facility scheme for testing the pile with static pull-out load

Explanations for the figures:

1 - Traverses;
2 - Flange;
3 - Flange mounting bolts;

4 - Hydraulic jack;
5 - Loading platform (consists of steel I-beams);
6 - The connection unit with the reinforcing cage of the pile (consists of a steel pipe and reinforcing bars welded to the reinforcing cage of the pile);
7 - Reinforcing cage of the tested pile (for indentation loads) and anchor piles (for pull-out loads);
8 - Measuring instruments (including stationary and moving parts instruments, as well as calipers);
9 - Test steel cap;
10 - Tested bored pile;
11 - Anchor bored piles.

5. The procedure of testing for static indentation load and calculation of the connection of the tested pile to the loading system.

1) Test procedure

The maximum static indentation load on the pile is 375 tons, the calculated working load on the pile is 250 tons.

The loading system will be installed on the test pile by means of a steel cap and welded to the anchor pile reinforcement cages. The static pressure test should be carried out in the following stages.

First stage

• The load on the pile will be increased in stages by 25% of the design load with 30 minute stabilization breaks up to 125%. During testing, the pile settlement rate should not exceed 0.25 mm for each loading stage, and the pile loading time to 100% should not exceed 2 hours.
• When the load on the pile reaches 125%, provide a break for 6 hours,
• The pile is unloaded in 4 stages, each time reducing the design load by 25% with breaks of 15 minutes.
• After unloading the pile to 0%, it is necessary to provide a break for 1 hour and take measurements.

Second stage

• Load the pile up to 125% of the design load and wait 30 minutes.
• Increase the load on the pile up to 150% of the design load.
• Wait 6 hours when the pile is loaded at 150% and hold the pile under load for 12 hours if the pile settlement rate does not exceed 0.25 mm within 1 hour. If the pile settlement rate does not exceed 0.25 mm in 1 hour, it should be kept under load for another 12 hours.
• Unload the pile in 4 stages, each time reducing the design load by 25% with breaks of 15 minutes.
• After unloading the pile to 0%, it is necessary to provide a break for 1 hour and take measurements.

2) Checking the strength of the connection of the pile to the load system for pulling out:

Maximum load per 1 anchor pile - T_{anc} = 187.5 tons
When applying force to 10 reinforcing bars with a diameter of 28 mm, 1 bar has a load T = 187.5 / 10 = 18.75 tons
Cross-sectional area $A_{sec-T28}$ = 6.158 cm2
Checking the tensile strength of the reinforcement:
$T/A_{sec-T25}$ = 18.75/6.158 = 3.04 t/cm2 < 3.671 t/cm2 – the strength condition is met.

3) Checking the conditional yield strength of reinforcing bars connected to the loading system:

Maximum load per 1 anchor pile - T_{anc} = 187.5 tons

When applying force to 10 reinforcing bars with a diameter of 28 mm, 1 bar has a load T = 187.5 / 10 = 18.75 tons

Cross-sectional area $A_{sec-T28}$ = 6.158 cm2

In this case

$T/ A_{sec-T28}$ = 18.75/6.158 = 3.04 t/cm2 < 4.0 t/cm2 – the strength condition is met.

4) Checking the strength of the welded joint of the reinforcement bars connected to the loading system

The conditional yield strength of the welding material is assumed to be 380 MPa = 3.875 t/cm2

Permissible tensile strength σ k = 1.1 t/cm2

Accepted surface resistance σ k = 0.9 t/cm2

Weld length L = 20 cm + 20 cm (two-sided welding)

Weld thickness t = 8 mm

Estimated length of the weld L'=20-2*0.8=18.4 cm.

Strength of one-sided weld

σ k x L' x t = 0.9 t/cm2 x 18.4 cm x 0.8 cm = 13.2 t

13.2 x 2 = 26.4 t > 18.7 t - maximum pile load

The strength condition of the welded joint is fulfilled.

5. Table of test results

The results of pile tests for static indentation load		
Overall dimensions of the tested bored pile	**D=1,2m** **L=18m**	**Date and time of test start: 04/29/2022, 11:00 am** **Date and time of test completion: 04/30/2022, 06:50 pm**
Pile location:	**Bridge across the river Velveli-chay on the Baku-State Border of the Russian Federation highway**	**Customer:** **Contractor:**
Total time spent (hours)	**18 hours 45 minutes**	**Engineer: Imamverdiev R.S.**
Design (working) load on the pile	**2500kN**	**Testing organization: "Azertunelsutikinti" LLC**
Maximum test load	**3750 kN**	

Applied load as a percent of design load	Spent time			Величина приложенной нагрузки		Test results						
						Tested pile					Anchor piles	
	Real time	Total time spent	Time interval	kN	Bar	1	2	3	4	Average value of results	1	2
25%	11:00	0:00:00	0:00	62,5	6,25	0.1	0.00	0.08	0.04	0.06	0.03	0.02
	11:05	0:05:00	0:05:00	62,5	6,25	0.10	0.00	0.08	0.04	0.05	0.03	0.02
	11:20	0:20:00	0:15:00	62,5	6,25	0.10	0.00	0.08	0.04	0.05	0.03	0.02
	11:35	0:30:00	0:15:00	62,5	6,25	0.09	0.00	0.08	0.04	0.05	0.04	0.02
50%	11:35	0:30:00	0:00	125,0	12,5	0.24	0.00	0.19	0.16	0.15	0.02	0.02
	11:40	0:35:00	0:05:00	125,0	12,5	0.24	0.00	0.19	0.16	0.15	0.02	0.02
	11:50	0:45:00	0:10:00	125,0	12,5	0.24	0.00	0.19	0.16	0.15	0.03	0.00
	12:05	1:00:00	0:15:00	125,0	12,5	0.24	0.00	0.19	0.16	0.15	0.03	0.00
75%	12:05	1:00:00	0:00:00	187,5	18,75	0.23	0.00	0.19	0.16	0.15	0.05	0.02
	12:10	1:05:00	0:05:00	187,5	18,75	0.17	0.00	0.12	0.16	0.12	0.10	0.08
	12:20	1:15:00	0:10:00	187,5	18,75	0.31	0.04	0.18	0.19	0.18	0.19	0.18
	12:35	1:30:00	0:15:00	187,5	18,75	0.31	0.04	0.18	0.19	0.18	0.20	0.20
100%	12:35	1:30:00	0:00:00	250,0	25,0	0.31	0.04	0.14	0.20	0.17	0.30	0.29
	12:40	1:35:00	0:05:00	250,0	25,0	0.31	0.04	0.14	0.20	0.17	0.30	0.30
	12:50	1:45:00	0:10:00	250,0	25,0	0.31	0.04	0.14	0.20	0.17	0.30	0.30
	13:05	2:00:00	0:15:00	250,0	25,0	0.34	0.04	0.14	0.20	0.18	0.30	0.30

	13:05	2:00:00	0:00:00	312,5	31,25	0.58	0.49	0.34	0.36	0.44	0.34	0.42
	13:10	2:05:00	0:05:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.44
	13:20	2:15:00	0:10:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	13:35	2:30:00	0:15:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	14:05	3:00:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	14:35	3:30:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	15:05	4:00:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
125%	15:35	4:30:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	16:05	5:00:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	16:35	5:30:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.34	0.43
	17:05	6:00:00	0:30:00	312,5	31,25	0.59	0.50	0.34	0.36	0.44	0.34	0.49
	17:35	6:30:00	0:30:00	312,5	31,25	0.59	0.50	0.34	0.36	0.44	0.50	0.51
	18:05	7:00:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.54	0.53
	18:35	7:30:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.55	0.54
	19:05	8:00:00	0:30:00	312,5	31,25	0.59	0.49	0.34	0.36	0.44	0.56	0.51
	19:05	8:00:00	0:00:00	250,0	25,0	0.34	0.39	0.02	0.09	0.21	0.53	0.49
100%	19:10	8:05:00	0:05:00	250,0	25,0	0.34	0.39	0.02	0.09	0.21	0.53	0.48
	19:20	8:15:00	0:10:00	250,0	25,0	0.34	0.39	0.02	0.09	0.21	0.53	0.48
	19:20	8:15:00	0:00:00	187,5	18,75	0.17	0.39	0.14	0.04	0.09	0.46	0.44
75%	19:25	8:20:00	0:05:00	187,5	18,75	0.17	0.39	0.14	0.04	0.09	0.46	0.44
	19:35	8:30:00	0:10:00	187,5	18,75	0.17	0.39	0.14	0.04	0.09	0.46	0.44
	19:35	8:30:00	0:00:00	125,0	12,5	0.17	0.39	0.14	0.04	0.09	0.46	0.44
50%	19:40	8:35:00	0:05:00	125,0	12,5	0.17	0.39	0.14	0.04	0.09	0.46	0.44
	19:50	8:45:00	0:10:00	125,0	12,5	0.17	0.39	0.14	0.04	0.09	0.46	0.44
	19:50	8:45:00	0:00:00	62,5	6,25	0.14	0.15	0.44	0.31	0.18	0.41	0.38
25%	20:55	8:50:00	0:05:00	62,5	6,25	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	21:05	9:00:00	0:10:00	62,5	6,25	0.13	0.15	0.44	0.31	0.18	0.41	0.38
	21:05	9:00:00	0:00:00	0,0	0,0	0.14	0.14	0.45	0.31	0.19	0.41	0.38
	21:10	9:05:00	0:05:00	0,0	0,0	0.14	0.14	0.45	0.31	0.19	0.40	0.38
0%	21:20	9:15:00	0:10:00	0,0	0,0	0.13	0.11	0.42	0.28	0.17	0.37	0.36
	21:35	9:30:00	0:15:00	0,0	0,0	0.14	0.14	0.45	0.31	0.19	0.41	0.38
	22:05	10:00:00	0:30:00	0,0	0,0	0.14	0.14	0.45	0.31	0.19	0.40	0.38
125%	22:05	10:00:00	0:00:00	312,5	31,25	0.17	0.39	0.14	0.04	0.09	0.46	0.44

	22:10	10:05:00	0:05:00	312,5	31,25	0.17	0.39	0.14	0.04	0.09	0.46	0.44
	22:20	10:15:00	0:10:00	312,5	31,25	0.17	0.39	0.14	0.04	0.09	0.46	0.44
150%	22:35	10:30:00	0:00:00	375,0	37,5	0.58	0.49	0.34	0.36	0.44	0.44	0.42
	22:40	10:35:00	0:05:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.44
	22:50	10:45:00	0:10:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	23:05	11:00:00	0:15:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	23:35	11:30:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	00:05	12:00:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	00:35	12:30:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	01:05	13:00:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	01:35	13:30:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	02:05	14:00:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.44	0.43
	02:35	14:30:00	0:30:00	375,0	37,5	0.59	0.50	0.34	0.36	0.44	0.47	0.49
	03:05	15:00:00	0:30:00	375,0	37,5	0.59	0.50	0.34	0.36	0.44	0.50	0.51
	03:35	15:30:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.54	0.53
	04:05	16:00:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.55	0.54
	04:35	16:30:00	0:30:00	375,0	37,5	0.59	0.49	0.34	0.36	0.44	0.56	0.51
125%	04:35	16:30:00	0:00:00	312,5	31,25	0.27	0.39	0.34	0.34	0.34	0.46	0.44
	04:40	16:35:00	0:05:00	312,5	31,25	0.27	0.39	0.34	0.34	0.34	0.46	0.44
	04:50	16:45:00	0:10:00	312,5	31,25	0.27	0.39	0.32	0.32	0.33	0.46	0.44
100%	04:50	16:45:00	0:00:00	250,0	25,0	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	04:55	16:50:00	0:05:00	250,0	25,0	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:05	17:00:00	0:10:00	250,0	25,0	0.13	0.15	0.44	0.31	0.18	0.41	0.38
75%	05:05	17:00:00	0:00:00	187,5	18,75	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:10	17:05:00	0:05:00	187,5	18,75	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:20	17:15:00	0:10:00	187,5	18,75	0.13	0.15	0.44	0.31	0.18	0.41	0.38
50%	05:20	17:15:00	0:00:00	125,0	12,5	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:25	17:20:00	0:05:00	125,0	12,5	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:35	17:30:00	0:10:00	125,0	12,5	0.13	0.15	0.44	0.31	0.18	0.41	0.38
25%	05:35	17:30:00	0:00:00	62,5	6,25	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:40	17:35:00	0:05:00	62,5	6,25	0.14	0.15	0.44	0.31	0.18	0.41	0.38
	05:50	17:45:00	0:10:00	62,5	6,25	0.13	0.15	0.44	0.31	0.18	0.41	0.38
0%	05:50	17:45:00	0:00:00	0,0	0,0	0.12	0.13	0.15	0.14	0.14	0.41	0.38

	05:55	17:50:00	0:05:00	0,0	0,0	0.12	0.14	0.14	0.12	0.13	0.41	0.38
	06:05	18:00:00	0:10:00	0,0	0,0	0.11	0.13	0.13	0.11	0.12	0.41	0.38
	06:20	18:15:00	0:15:00	0,0	0,0	0.10	0.12	0.11	0.11	0.11	0.41	0.38
	06:50	18:45:00	0:30:00	0,0	0,0	0.09	0.07	0.08	0.09	0.08	0.41	0.38

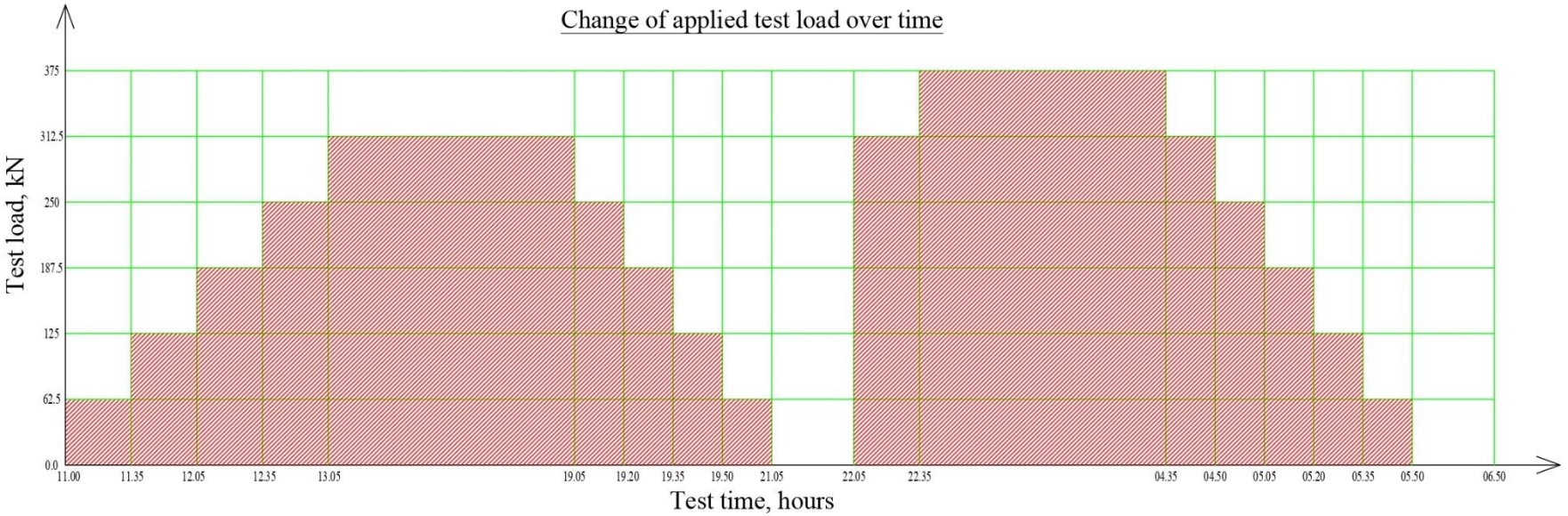
Notes to table

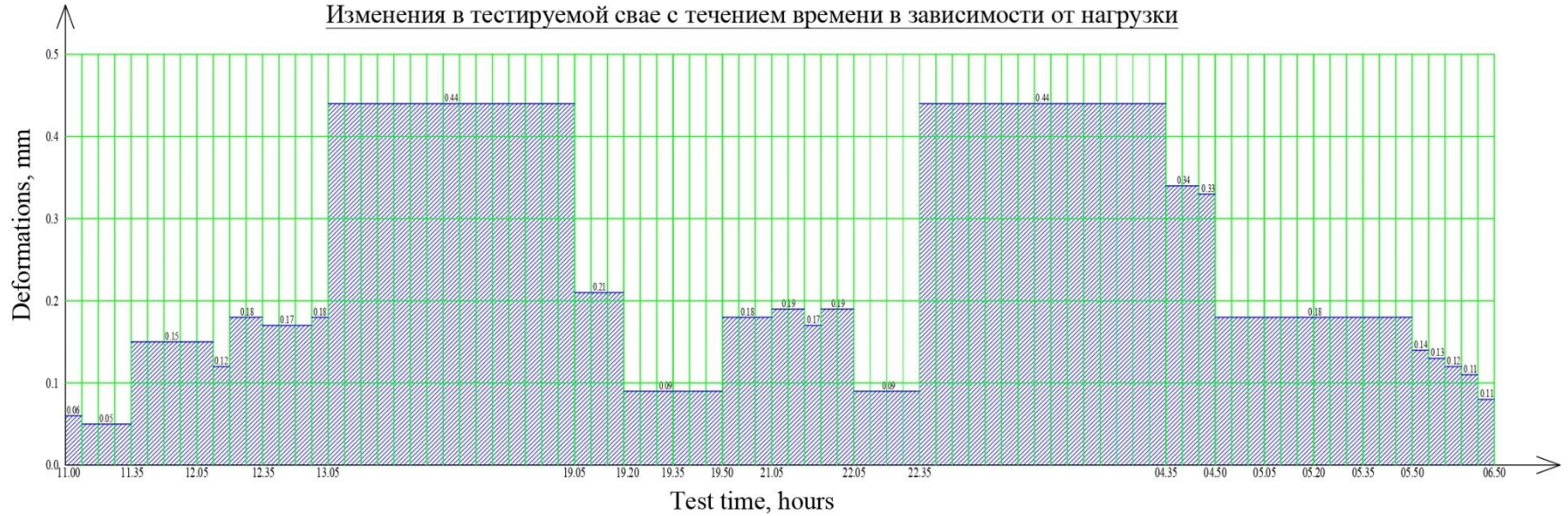
The test is carried out at intervals of not more than 15 minutes until the load stabilizes, and the load time should not exceed 2 hours. Stabilization is considered achieved when the pile settlement rate, measured for at least 15 minutes at a constant load, is less than 0.25 mm/h.

6. Conclusions

During the tests, the test load was increased to 3750 kN (150% of the design load on the pile). The pile, tested at this maximum test load, had settled down to 0.44 mm at the end of the loading phase. After removing the load from the pile, a deformation of 0.14 mm was observed. The test results are presented in the form of a diagram.

According to the design documentation, the maximum allowable deformation of the pile can be 0.90 mm, and the results of the tests carried out meet the established criteria for the strength of the pile for static indentation load.


Change of applied test load over time
Test load, kN
375
312.5
250
187.5
125
62.5
0.0
11.00
11.35
12.05
12.35
13.05
19.05
19.20
19.35
19.50
21.05
22.05
22.35
04.35
04.50
05.05
05.20
05.35
05.50
06.50
Test time, hours


Изменения в тестируемой свае с течением времени в зависимости от нагрузки
Deformations, mm
0.5
0.4
0.3
0.2
0.1
0.0
0.06
0.05
0.15
0.12
0.18
0.17
0.18
0.44
0.21
0.09
0.09
0.18
0.19
0.17
0.19
0.09
0.44
0.34
0.33
0.18
0.18
0.14
0.13
0.12
0.11
0.11
11.00
11.35
12.05
12.35
13.05
19.05
19.20
19.35
19.50
21.05
22.05
22.35
04.35
04.50
05.05
05.20
05.35
05.50
06.50
Test time, hours