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USING OF DYNAMIC AND STATIC LOAD PILING TESTS IN ASTANA, KAZAKHSTAN

In this paper the analysis results of precast piles different tests are presented. Extreme soil conditions of Astana (Kazakhstan) involve realizing the work precast piles in various soil ground and interaction soil ground and piles. There were carried out dynamic and static load tests of piles in extreme soil ground conditions in Astana. Based on data results of pile foundations the piles bearing capacity was determined. According to the results of DLT with PDA of driving piles (30.0 cm) the bearing capacity of the piles is 911 kN. The bearing capacity of the driven piles according to the results of SLT amounted to be 878 kN. Soils physic-mechanical properties in extreme conditions of Astana along with graphs of dependence are between settlement and load. The precise analysis of climatic and geological factors of the construction sites is shown. Investigations method for precast concrete piles testing is presented. Dynamic load test methodology in Astana for concrete piles testing is shown. These investigations are important for of Pile-Soil interaction on problematical soil ground.

***Keywords:** pile foundations, load test, bearing capacity, conditions.*

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ВИКОРИСТАННЯ ДАНИХ ВИПРОБУВАНЬ ПАЛЬ СТАТИЧНИМИ ТА ДИНАМІЧНИМИ НАВАНТАЖЕННЯМИ В АСТАНІ, КАЗАХСТАН

Наведено результати аналізу різних випробувань збірних паль. Оцінено роботу збірних паль у надзвичайних ґрунтових умовах Астани (Казахстан) та їх взаємодію з оточуючим ґрунтом. Представлено дані статичних та динамічних випробувань паль у надзвичайно складних ґрунтових умовах. Визначено несучу здатність паль з використанням отриманих результатів. Відповідно до результатів випробувань паль (30,0 см), несуча здатність склала 911 кН, несуча здатність рухомих паль залежно від результатів ТЗ становила 878 кН. Представлене дослідження має важливе значення для розуміння взаємодії системи паля – ґрунт з проблематичним ґрунтом.

***Ключові слова:** пальовий фундамент, випробування навантаженням, несуча здатність, геологічні умови.*

Introduction. Unique buildings and structures are built in the new capital of Astana. There are Trade & Entertaining Centre «Mega Plaza Astana» and scientific and educational complex «Nazarbayev University». The design of foundations requires careful analysis of natural climatic, geological factors: air temperature, winter duration, snow cover thickness, soils thermal properties.

Recent sources of research and publications analysis. A. Zh. Zhussupbekov, M. K. Syrlybaev, R. E. Lukpanov and A. R. Omarov [3 – 5] have investigated dynamic and static piling tests applications of Astana, A. Zh. Zhussupbekov, R. Zh. Lukpanov, A. L. Omarov have investigated the Results of Dynamic (Pile Driving Analysis) and Traditional Static Piling Tests in Capital of Kazakhstan.

Identification of general problem parts unsolved before. The design of foundations requires a careful analysis of natural climatic, geological factors such as air temperature, winter duration, snow cover thickness, thermal soils properties not analyzed before in this region.

The **goal** of the research is to analyze the interaction of extreme soil ground conditions with precast piles under various loads.

Basic material and results. Engineering-geological conditions of the site are: construction site of the Trade & Entertaining Centre «Mega Plaza Astana»; the site of researches for construction is on the Northeast side of Kazakhstan capital Astana, on the left side of the Esil river between two streets of Kabanbai batyr avenue and Ryskulov street in Astana (Kazakhstan).

Figure 1 – Construction sites in Astana (Kazakhstan)

Pile tests were performed in accordance with the requirements of GOST 5686-94 «Soils. Methods of field testing with piles».

Results of soil construction site physic-mechanical properties are resulted from Table 1.

Table 1 – Physic-mechanical properties of site soil

Type of soil	*E*, MPa	*C*, kPa	*φ*, deg	*ρ* g/cm^3
Poured soils	-	-	-	1,87
Muddy loams	4,0	14	10	1,78
Loams	7,0	12	20	2,04
Sands of average size	17,0	1	35	1,92
Semi-gravel sands	21,0	-	38	1,92
Gravel soils	21 – 23,0	-	-	2,00
Clayey soils	12,0	-	28	1,95
Gruss - rock debris soils	23 – 29,0	-	-	2,12-2,20
Sands stones	8,0	-	-	2,57

Construction site of Scientific & Educational complex «Nazarbayev University». Astana, Kazakhstan: the construction site is on the Northeast side of Astana, on the left side of the Esil river (Table 2).

Table 2 – Physic-mechanical properties of site soil

Type of soil	*E*, MPa	*C*, kPa	*φ*, deg	*ρ* g/cm^3
Poured soil	-	-	-	1,87
Loams	13	21	31	1,97
Sands of average size	17	2	35	1,47
Gravel sands	21	1	38	1,61
Gravel soils	23	-	-	2,00
Loams	16	35	33	2,00
Silty medium gravel	29	-	-	2,20
Sands stones	32	2	-	2,40

Precast concrete pile: static tests were carried out on precast concrete pile with a total length of 6.2 m. with cross-section 30×30 cm (Fig. 2). Pile is applied by bituminous (corrosion protection) material and marked every 0.1 m. The purpose of testing is estimation of the bearing capacity and comparison of the results pile foundations. For driving piles used driving rig Junttan PM-20 with hydraulic hammer NNK-5A part of blow weight of 5.0 tons. Field works are made in accordance with the requirements [1, 2].

Investigation method for precast concrete pile: before driving test piles have been marked every of 10 cm on all length (L = 6.2 m). During the first stage of dynamic tests carrying out the loads were made by C10-30 (28 piles). Piles immersed in the soil to the absolute mark of the pile point 337.24 m.

Figure 2 – Precast concrete pile on the site

In the first stage, piles were driving according to preliminary criteria for a stop: on 911 kN working load, pile refusal should be equal 0.83 cm; on 620 kN working loading, pile refusal should be equal 0.56 cm. The results of dynamic tests is given in Tab. 3.

Table 3 – Results of dynamic tests

Number of pile, across	Embedded depth, m	Design load, kN	Refusal of pile at driving, cm
6C10-30, 30×30	8.2	620	0.56
9C10-30, 30×30	9.1	878	0.59
2C10-30, 30×30	8.4	911	0.83

Dynamic load test (DLT): in Kazakhstan experimental piles with dynamic loads production was carried out on October 27, 2016, using a Junttan PM-20 pile-rig with an NNK-5A hydraulic hammer, with a 5,000 kg impactor mass and a weight of 835 kg. Re-driving of the test piles was carried out by three and five hammer blows. To determine the bearing capacity, the largest average failures were obtained when piles were pierced after their «rest». The strain gauges with the length of 10 cm were attached on piles top before starting re-driving. Strain gauges had been fixed on 60 cm from the pile head. Allowable piles bearing capacity with safety factor (FS = 1.4) equal to 620 kN [2-5]. The piling of the tested piles was carried out on October 20 and 21, 2016, temperature -5ºC, using a Junttan PM-20 pile-driving machine with a hydraulic hammer, NNK-5A, with a shock weight of 5000 kg and a headgear weighing 835 kg. When driving the piles, wooden pads, 10 cm thick, were installed on the metal cushion for damping hammer impact forces on the reinforced concrete pile head. Before the start of piling the test pile on its surface, preliminary, the paint was divided over the entire pile length 1 m, and on the last meter, the proposed depth of immersion, after every 0.1 m. In the process of pile driving, counting the number of hammer blows for each pile dive meter was counted and on the last meter for every 10 cm of driving. At the same time, the impact hammer heigh was recorded. The results of piles re-drive is given in Tab. 4.

Table 4 – Results of piles re-drive

Number of pile	Refusal of pile at re-driving, cm	Particular value of the limit resistance of piles, kN
6C10-30, 30×30	0,57	465
9C10-30, 30×30	0,3	658
2C10-30, 30×30	0,28	685

Static tests carrying out: driving test piles was carried out in 6.2 m. The technology of precast concrete piles static loading test was done in according with the requirements of GOST 5686-94, i.e. according to the GOST requirements precast pile is tested after 6 days «rest». Testing platform presented system from steel, which consisted of metallic beam. For platforms applied concrete blocks, total weight was 185 tons. The results of the first stage static tests is given in Tab. 5.

Table 5 – The first stage static tests results

Number of steps	Design load, kN	Settlement, Mm	Steps duting stability
Load			
1	106	0,26	1
2	212	0,97	1,5
3	318	1,93	2
4	398	2,74	2
5	478	3,66	2
6	558	4,59	2
7	638	5,61	2
8	718	6,70	2
9	798	7,73	2
10	878	8,95	3
Unload			
1	718	8,88	15 min
2	558	8,31	15 min
3	398	7,55	15 min
4	212	6,04	15 min
5	212		1

The vertical load was created with hydraulic jack CLS 2006. The load was recorded with pressure-measuring manometer H4049L from 0 to 1000 bar. Measurements of each pile movements were made by two deflection gauge 6PAO, which have been marked every of 0.01 mm. Safety factor (SF=1.2) [2]. The graph of dependence of Settlement S from Load P is shawn in Tab. 3.

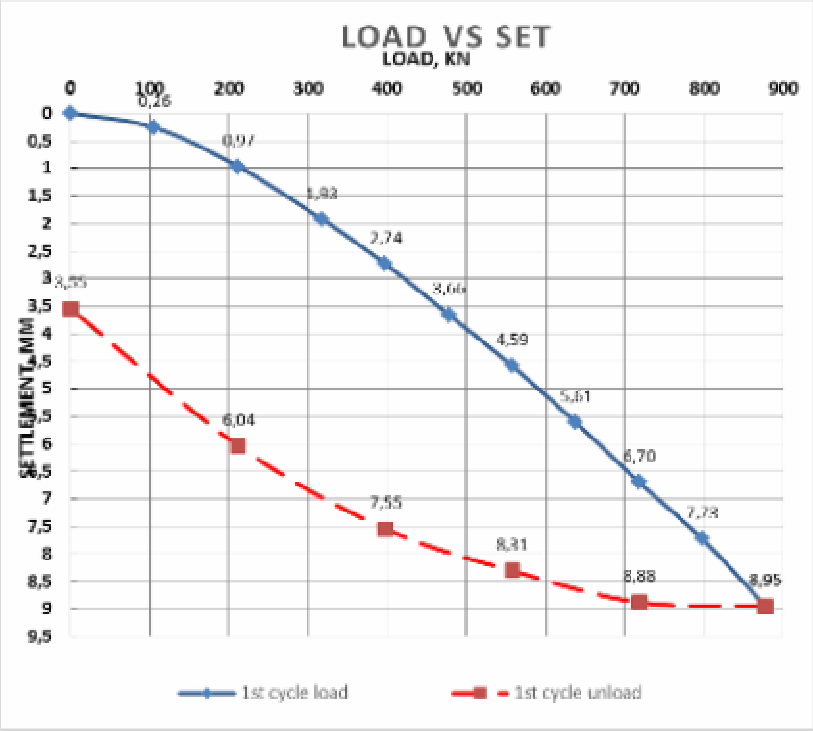

Figure 3 – Graph of dependence of Settlement S from Load P (by GOST 5686-94)

Conclusions. The testing aim is to determinate pile foundations bearing capacity in extreme ground soils of Astana, Kazakhstan. According to the results of DLT with driving piles PDA (30.0 cm), the piles bearing capacity is 911 kN. The driven piles bearing capacity according to the results of SLT is 878 kN. These investigations are important for Pile-Soil interaction comprehension on problematical soil ground.

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