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A. Tulebekova*[1], A. Zhussupbekov[2], Ye. Ashkey[3], A. Zhankina[4]

[1,4] L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan
[2]Saint-Petersburg State University of Architecture and Civil Engineering, Saint –Petersburg, Russia
[3]KGS- Astana, LTD, Nur-Sultan, Kazakhstan
Corresponding author: krasavka5@mail.ru

Features of static pile load test

Abstract. Pile foundations are commonly used in engineering practice to transfer the loads from heavy structures such as high-rise buildings to competent soil strata. In this manner, such complications as unfavorable geological conditions, compressible soil layers, and high levels of groundwater are avoided. Different types of piles are used in construction work. The specific type of pile used depends on the type of loading, the foundation soil, and the location of the groundwater table. The technical progress of large, bored piles and the continuous improvements of construction procedures and piling equipment today have created new possibilities. This paper describes a series of pile load tests that were performed in the capital city of Nur-Sultan, Kazakhstan. The control equipment, technological features are important for detailed information about the process of testing and the associated results make them more accurate and reliable.
Keywords: pile, static test, load, equipment, soil

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Introduction

As world practice shows construction development directly reflects the economical position of the state in the whole world, it is one of the relevant fields for future advance and development. The first and the main of them is that the application of international practice improves the quality, safety, and reliability of construction [1-4]. The causes of numerous disasters that occurred at different times on construction sites in different countries of the world were analyzed and considered in the latest version of standards. Some aspects in international standards balanced system make construction easier, faster, and more economical [5-7].

The international relations expansion including investments of domestic companies in construction abroad, and foreign companies in the construction projects in the Republic of Kazakhstan, entry into the Eurasian Union and the World Trade Organization requires contingence of the normative base, including designing, construction, and operation of buildings and structures [8-9]. Presently, the following types of pile foundations are used in Kazakhstan:

- Drilled piles using the hydro-hammer of Junttan, Banut-650, Rapat Company.
- Drilled piles using diesel-fuel hammer types MSDSH1, MSDT1.
- Piles arranged by impression using the device of Taizer Company.
- Bored piles with pipe casing using traditional pile foundation technology.
- Bored piles protected by pipe casing construction using the modern device of «Bauer», «Casagrande» Company.
- Bored piles using flight auger technology of «CFA» [10].
- Bored piles using short auger construction technology of SM-70, SBU-100, «Klemm», «Soilmec».
- Bored piles by DDS technologies (FDP) using the device of «Bauer» Company.
- Piles installed using the «Jet grouting» process.

Research methods

Static load test should be carried out for driving piles after the «rest» and for bored piles after achievements of the concrete strength of more than 80%. For static load tests the following equipment is used: hydraulic jack SMJ-158A - 200 ton; caving in-measurers of the type 6PAO.The pressure in the jack was created with the help of manual oil pump station MNSR-400 with power up to 800 kg/cm², the moving of steel piles was fixed by caving in-measurers of the type 6-PAO, which were installed on both sides of unmovable bearings with the benchmark system.

The first record was performed just after putting the loading, then consequently 4 records with an interval of 15 minutes, 2 records with an interval of 30 minutes, and further for every hour until the conditional stabilization of pile settlement. For the criterion of conditional stabilization of pile, the settlement was taken when the speed of settlement of piles on the given stage of loading did not exceed 0.1 mm during the last 1-2 hours of observations. Reloading (unloading) conducted half the stages of the loading.

The construction site is located in the capital of the Republic of Kazakhstan Nur-Sultan city, on the left bank of the Yesil River. The city's territory is located on the Kazakh shield and does not have tectonic movements, therefore its territory is not considered seismic [11]. The building sites in the territory of Nur-Sultan city are taken as the research objects characterizing typical engineering-geological conditions of this region. For each allocated engineering-geological element private values of parameters of physical-mechanical properties, tests by laboratory methods, characteristics of soil are presented in Table 1.

Table 1

Soil investigations

Bottom of the soil layer, m		Thickness of soil layer, m	Description of soil layer	Physical-mechanical properties of soil			
depths	ground level			E, MPa	C, kPa	φ	ρ, g/cm^3
0.4÷0.8	345.76÷346.08	0.4÷0.8	Clay	15	40	14	1.95
13.3÷12.7	333.26÷333.78	12.3÷12.5	Hard clay	26	57	18	2.00
22.3÷22.9	323.58÷324.26	9.0-10.2	Sand with gravel	32	2	38	2.60
26.0	320.76÷321.16	3.4-3.5	Sand	34	2	40	2.66

Field static load tests were carried out for CFA piles no. CFA1, CFA2, with a diameter of 600 mm. Under GOST 5686-12 [12], the equipment of the soil testing unit with static loading should include the following (see Figure 1-2): a device for loading piles (typically this consists of jacks); a supporting structure for receiving reactive forces (typically this is a system of beams with anchor piles); a device for measuring pile movements during testing (typically this consists of a system of benchmarks with suitable measuring devices). The distance between the testing piles till anchoring pile is 5d<L1>2.5m.

Reloading was conducted in stages 800kN and 400kN (see Table 2, Figure 3).

Figure 1. Field static load test of CFA1 on construction site (Building 3)

Figure 2. Field static load test of Casing2 on construction site (Building 5)

Table 2

Data of tests

No. of the test pile	Length of the pile, m	∅ pile, mm	Reinforcement	Concrete type	Absolute levels of the pile, m			Pile length of in soil, m
CFA1	10.5	600	8∅ 20A-III	B25	347.06	346.56	336.56	10.0
CFA2	10.5	600	8∅ 20A-III	B25	347.06	346.56	336.56	10.0
Casing 1	10.5	630	8∅ 20A-III	B25	347.06	346.56	336.56	10.0
Casing 2	10.5	630	8∅ 20A-III	B25	347.06	346.56	336.56	10.0

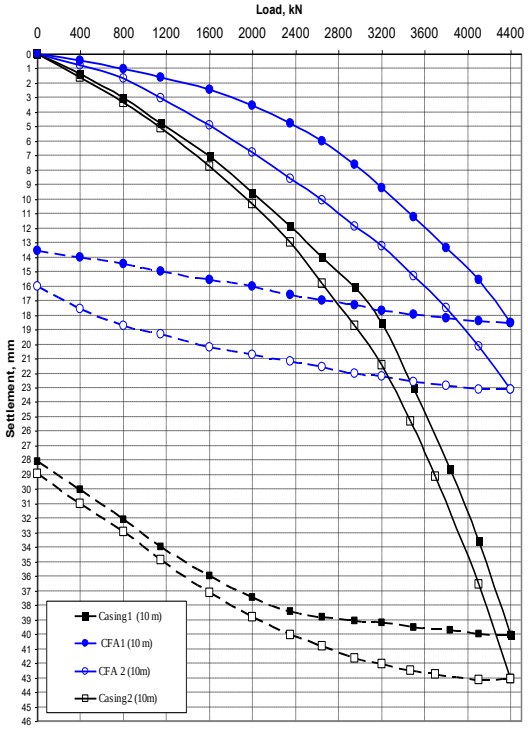

Figure 3. Diagram of load dependence of pile head settlements to determine the bearing capacity of CFA and Casing piles [13]

The construction site (Nazarbayev Intellectual School) is located in Nur-Sultan city. The city's territory is located on the Kazakh shield and does not have tectonic movements, therefore its territory is not considered seismic.

According to the soil investigations (see Table 3) on the construction site, the following soil formation has been settlement [14].

Table 3

Soil investigations

Geological engineering element	Intercept cohesion, кPa	The angle of internal friction, °	Modulus of deformation on saturation, MPa	Soil density, g/cm^3
Water loam	3.5	16.3	6.19	2.03
Loam aQII –IV	16.2	17	7	1.99
Gravel sand aQII-IV	1	38	21	2.00
Clay soil	22	17	13.0	2.09

The project provided for static tests on three bored piles: C6-30 №293, 453, 750 on the depth 5.4m.Static load test carried out for driving piles after the “rest” and for driven piles after achievements of the concrete strength more than 80%. For static load tests the following equipment is used: hydraulic jack DU-100P - 100 ton, manometer MTP-160, caving in-measurers of the type 6PAO. Table 4, Figures 4-6 present the results of static pile tests.

Table 4

Results of static load test

Pile number	№ 293	№ 453	№ 750
Embedded depth, m	7.00	9.25	10.25
Driving depth, m	5.4	5.4	5.4
Settlement, mm	5.65	7.53	14.69
Applied load, kN	642.8	642.8	642.8
Max.load, kN	1200	1200	1200

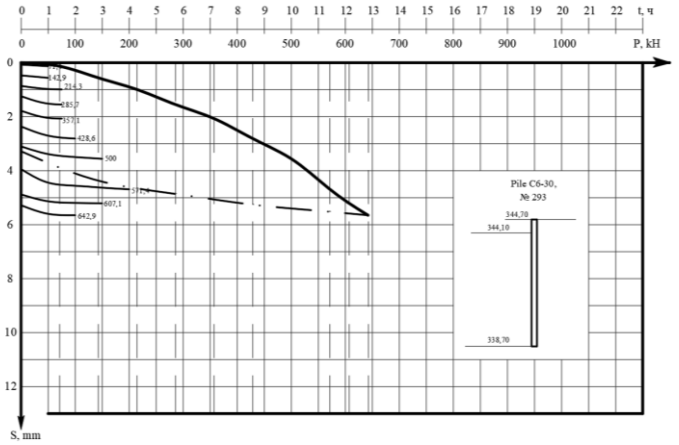

Figure 4. Correlation between settlement S and load P, the results of field static test on pile293 [9]

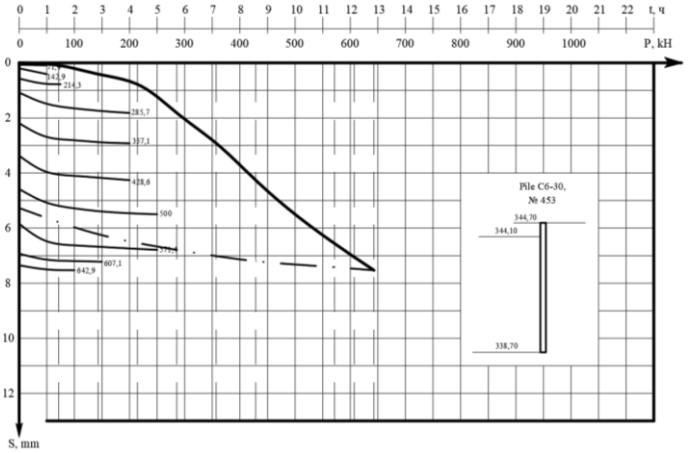

Figure 5. Correlation between settlement S and load P, the results of field static test on pile453

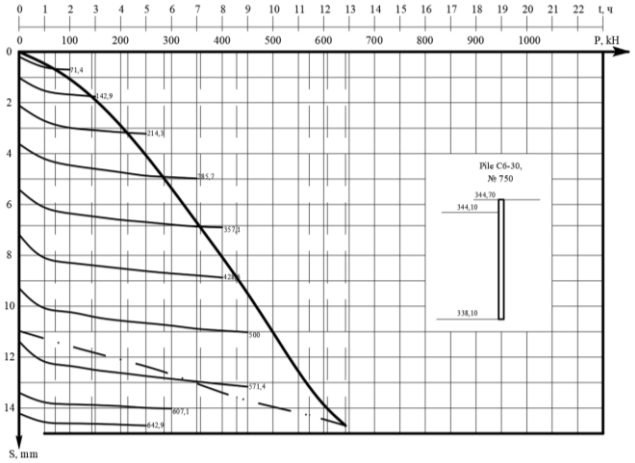

Figure 6. Correlation between settlement S and load P, the results of field static test on pile750

Results and discussion

The analysis of static tests at the construction sites showed that the tests were reliable and gave detailed information about the process of testing and the associated results. Requirements of standards of GOST 5686-12 for equipment and measuring device are presented in Table 4. Experience has shown that tests conducted according to GOST standard are accurate and reliable

Table 5

Features of applied equipment and measuring device by GOST

Measurement	Equipment and measuring device
To apply load	jack
load measurement on the pile head	manometer
load measurement over the entire length of the pile	axial displacement transducer visual control
measuring the axial displacement of the head	lateral displacement transducer of the head
lateral displacement measurement of the head	optical instrumental control

Conclusion

An important stage of the construction is to investigate the soil conditions in the area of the proposed works in the field conditions. They are carried out before designing the facility. In the course of field static tests, the degree of deformation of the ground under the influence of various factors is determined. During the operation of the constructed building, the ground beneath it is subjected to static loads, under the influence of which there are deformation changes, the degree of which depends on the parameters of the soil. Due to the fact that the static tests use natural (conventional in material, design, and size) piles, and the load on the foundation is as close to the operating load in size and nature, the static method of testing piles is considered to be the most reliable and objective, which has been shown in practice.

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А.С.Тулебекова[1], А.Ж.Жусупбеков[2], Е.Ашкей[3], А.Жанкина[4]

[1,4]Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Нұр-Сұлтан, Қазақстан
[2]Санкт-Петербург мемлекеттік сәулет-құрылыс университеті, Санкт-Петербург, Ресей
[3] ЖШС KGS-Astana, Нұр-Сұлтан, Қазақстан

Қадалармен топырақтың статикалық сынақтарын жүргізу ерекшеліктері

Аңдатпа. Қадалық іргетастар, әдетте, инженерлік тәжірибеде биік ғимараттар сияқты ауыр құрылымдардан жүктемелерді беру үшін қолданылады. Осылайша, қолайсыз геологиялық жағдайлар топырақтың сығылған қабаттары және жер асты суларының жоғары деңгейі сияқты

асқынулардың алдын алуға болады. Құрылыс жұмыстарында әртүрлі қадалар қолданылады. Қолданылатын қадалардың түрі жүктеме түріне, топыраққа, іргетасқа және жер асты суларының деңгейіне байланысты. Техникалық прогресс қадаларды қағуға арналған жабдықты үнемі жетілдіру үшін бүгінде жаңа мүмкіндіктер туғызды. Бұл жұмыста Қазақстанның астанасы Нұр-сұлтан қаласында өткізілген қада жүктемесін сынау сериялары сипатталады. Сынақ жабдықтары, технологиялық ерекшеліктер сынақ процесі және олармен байланысты нәтижелер туралы егжей-тегжейлі ақпарат алу үшін маңызды. Бұл оларды дәлірек және сенімді етеді.

Түйін сөздер: қадалар, статикалық сынақтар, жүктеме, жабдықтар, топырақ

А.С.Тулебекова[1], А.Ж.Жусупбеков[2], Е.Ашкей[3], А.Жанкина[4]

[1,4]Евразийский национальный университет им. Л. Н. Гумилева, Нур-Султан, Казахстан
[2]Санкт-Петербургский государственный архитектурно-строительный университет, Санкт-Петербург, Россия
[3] ТОО KGS-Astana, Нур-Султан, Казахстан

Особенности проведения статических испытаний грунта сваями

Аннотация. Использование свайного фундамента обычно обусловлено наличием неустойчивого, слабого грунта на месте будущего строительства. Таким образом, удается решить проблему слабых грунтов и высокого уровня грунтовых вод. В строительстве используются различные типы свай. Тип применяемых свай зависит от вида нагрузки, грунта, фундамента и уровня расположения грунтовых вод. Технический прогресс, постоянное совершенствование оборудования для забивки свай создали сегодня новые возможности. В данной работе описывается серия статических испытаний грунта сваями, которые были проведены в столице Казахстана, городе Нур-Султан. Контрольное оборудование, технологические особенности важны для получения подробной информации о процессе испытаний и связанных с ними результатов, что делает их более точными и надежными.

Ключевые слова: свая, статические испытания, нагрузка, оборудование, грунты.

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Information about authors:

Tulebekova Assel Serikkyzy - Ph.D., Associate Professor in Department of Civil Engineering, L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan.

Zhussupbekov Askar Zhagparovich - Professor in Department of Geotechnics, Saint-Petersburg State University of Architecture and Civil Engineering, Saint –Petersburg, Russia.

Ashkey Yergen - Manager at KGS-Astana, LTD, Nur-Sultan, Kazakhstan.

Zhankina Aizhan - Ph.D. student in Construction, Department of Civil Engineering, L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan.

Тулебекова Әсел Серікқызы - «Ғимараттар және құрылыстарды жобалау» кафедрасының доценті, Ph.D., *Л*. Н. Гумилев атындағы Еуразия ұлттық университеті, Нұр-сұлтан, Қазақстан.

Жусупбеков Аскар Жагпарович - Геотехника кафедрасының профессорі, Санкт-Петербург мемлекеттік сәулет-құрылыс университеті, Санкт-Петербург қ., Ресей.

Ашкей Ерген - ЖШС KGS-Astana компанияның менеджері, Нұр-сұлтан, Қазақстан.

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