Geotechnical issues of testing piles on construction site of Astana

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ABSTRACT

At present time pile foundations are widely used for problematic soil grounds of structures. Such problematic soil grounds in North Kazakhstan, from 1998 were known new capital city Astana. Construction development of the capital city is important for the country which its aim is to be among of developed countries. In this direction of our country foreign investors use their techniques and technology in big project constructions and constructions of high rise buildings and structures. One of the topical problems of constructions from the point of economy effective designing and laying foundations in the difficult soil conditions. The big attention is given to the increase of labour productivity, quality and reliability of erected structures. With proper planning and design, efficient equipment and experienced personnel, high production rates can be achieved. Unfortunately, present Standards are confined application of modern technology of pile foundation installation, indicating incomplete usage of advanced technology. The paper include the results of static tests of piles by using different standards have some differences. Discussion of using control equipment's, technological features, advantages and disadvantages of aforementioned methodic might be important for understanding the difference points. Also paper presents recommendation for the future modernization of Kazakhstan Standards.

Keywords: pile; standard; test; foundation; soil

1 INTRODUCTION

At present time pile foundations are widely used for problematic soil grounds of structures. Such problematic soil grounds in North Kazakhstan, from 1998 were known new capital city Astana. Construction development of the capital city is important for the country which its aim is to be among of developed countries. In this direction of our country foreign investors use their techniques and technology in big project constructions and constructions of high rise buildings and structures [Tulebekova et al 2018; Zhussupbekov et al 2012].

One of the topical problems of constructions from the point of economy effective designing and laying foundations in the difficult soil conditions.

The big attention is given to the increase of labour productivity, quality and reliability of erected structures. With proper planning and design, efficient equipment and experienced personnel, high production rates can be achieved. Unfortunately, present Standards are confined application of modern technology of pile foundation installation, indicating incomplete usage of advanced technology.

The paper presents the analysis of the results of soils field tests by piles on the construction site "The USA Embassy" in Astana city.

The dynamic and static tests of soils on the field were carried out by steel piles according to the requirements of ASTM D8169 (USA) standard and the State Standard 5686-12, Kazakhstan.

2 PROJECT CONSTRUCTION SITE-EMBASSY OF USA IN ASTANA, KAZAKHSTAN

The construction site is located on the South-Eastern side of the capital of the Republic of Kazakhstan in Astana (the USA Embassy in Astana), on the right bank of the Esil River (see Fig. 1).

Fig.1 the USA Embassy in Astana

The geological conditions of the field are as follows: middle quaternary modern deposits of loam, clays with lenses of gravel sand and loam, gravel; alluvial deposits with loams having gravel, sandstone, aleurolite, gruss; aleurolite-alluvial deposits of middle Jurassic rocks (see

Fig. 2). All of the mentioned layers are under topsoil [Zhussupbekov et al 2019].
Groundwater level at the depth of 1.2-2.3m, the absolute marks of the level is 349.40÷347.70 m.

All soils are permeable. The permeability coefficients for permeable soils:

- alluvial loam and clays – 0.53 m/day;
- gravels – 55.5 m/day;
- eluvial loam – 0.0094 m/day;
- gruss-gravel 0.21-1.66 m/day.

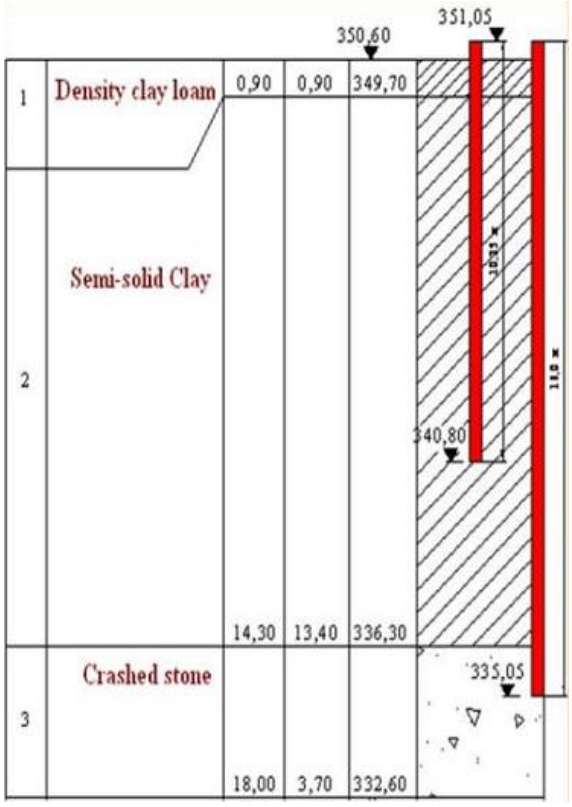

Fig. 2 Geology of construction site-Embassy of USA in Astana, Kazakhstan [Tulebekova et al 2015]

3 STATIC PILE TEST IN CONSTRUCTION SITE-EMBASSY OF USA IN ASTANA

The objective of static pile test is determination of settlement and bearing capacity of pile.

Anchoring-stubborn stand consist with main and subsidiary systems, four `anchor pile used for pile test.

Research polygon equipped by driving of testing and anchor piles, mounting of metalwork of anchoring stand, welding of anchor band [Awwad et al 2019].

Equipment which used in static pile test as follows:
- hydraulic jack CMZh58A, carrying capacity 2000 kN;
- hand pumping station MNSR with manometer MTP-160;
- two deflectometer - 6 PAO.

Jack with under base hand strain to pile and by up rag of it rod to basic hummer. Steel piles tested for 600 kN bearing load to press load 1200 kN, for 400 kN bearing load to press load 800 kN.

Field static pile test taken as follows:
- "rest "pile stand during 7-10 days instant ending of driving pile;
- loading of pile made by load up to 1200 kN and 800 kN;
- size of each step of load equal 50kN and 100 kN;
- unloading of testing piles made step by step;
- removal of samples from the deflectometer was carried out in the following order: first reading - right after the load application, and then sequentially through the four samples every 15 minutes of observation, two samples with an interval of 30 min and then every 60 minutes to conditional stabilization of deformation, until the precipitation rate of the pile at a given stage of loading will not exceed 0.1 mm in the last 60 minutes;
- removal of count elastic deformation made on each step on unloading over 15 min [Zhussupbekov et al 2016].

4 EXECUTION OF STATIC TEST OF STEEL PILES BEFORE HEIGHTENING OF PILE LENGTH

Graphic of dependence of settlement pile from load and variation of settlement on step of load received in test results.

A static pile test of steel H-piles was carried out after the "rest" of pile after driving. Results of static test of steel piles before heightening of pile length shown in Table 1 and Figure 3.

Table 1. Results of static test of steel H – piles

№	Number of pile	Embedded depth, m	Refusap of pile at driving,cm	Settlement,mm	Design load,kN	Applied load,kN	Max.load, kN
1	LT-1	7,00	1,00	43,03	600	900	1200
2	LT-4	9,25	1,25	42,55	600	900	1200
3	LT-6	10,25	1,25	40,25	600	600	1200
4	LT-7	8,00	1,56	40,88	400	600	800

Results of static test of steel piles after heightening of pile length shown in Table 3 and Figure 4-5. Results of static pile test showed that after heightening of pile length given best results.

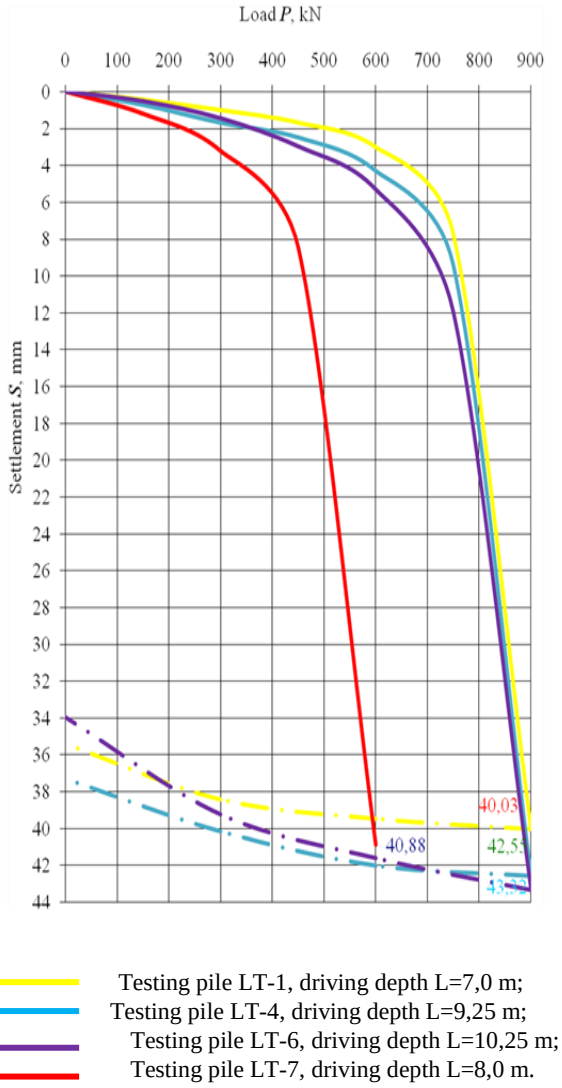

Fig. 3 Graphics of dependence of settlement S from load P regarding results of static pile tests before heightening of pile length (by ASTM D/D 1143M-07).

Table 2. Results of static test of steel H - piles

№	Number of piles	Embedded depth ,m	Driving depth, m	Refusal of pile at driving, after heightening pile , cm	Settlement, mm	Design load, kN	Applied load, kN	Max . load, kN
1	LT-3	10,00	13,00	0,32	7,00	600	1200	1200
2	LT-4	9,25	12,75	0,27	4,96	600	1200	1200
3	LT-5	8,25	11,00	0,27	4,42	600	1200	1200
4	LT-6	10,25	16,00	0,30	6,27	600	1200	1200

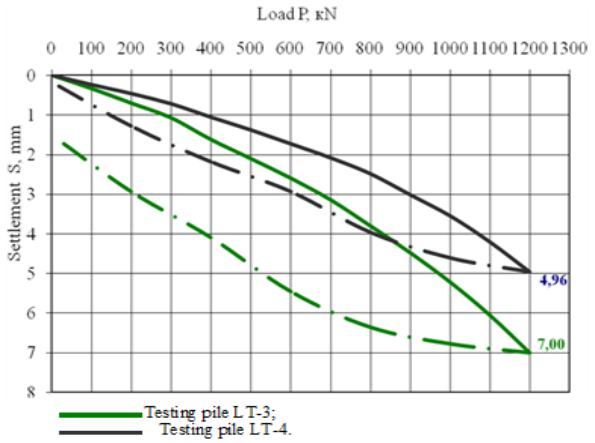

Fig. 4. Results of SLT pile numbers LT-3, 4.

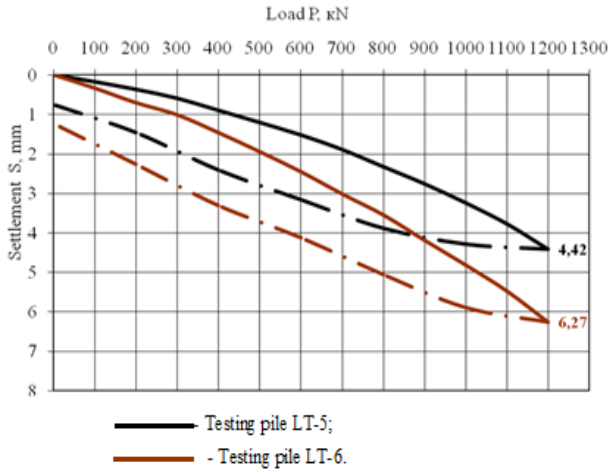

Fig. 5. Graphics dependence of settlement S from Load P for LT-5, 6 (by GOST 5686-94) [10].

5 CONCLUSIONS

Since 2012 year Kazakhstan Standard has not changed, ASTM standard was updated in 2018, and therefore takes latest developments in technology and technical terms and provides for the use of more modern equipment.

The purpose of testing is determination of bearing capacity and the penetration depth of immersion of composite piles in problematical ground soils of Atyrau region, Kazakhstan.

According to the results of DLT with PDA of driven piles (40×40 cm and lengths of 23 m and 26.75 m) the bearing capacity of the piles amounted to be 2143 kN. The bearing capacity of driven piles according to the results of SCLT amounted to be 2067 kN and 2042 kN.

The disadvantage of the offset limit load lies in the difficulty of determining the modulus of elasticity E for concrete piles and concreted pipe piles. Davisson's method needs the pile to be loaded to failure to be applicable.

We have to be aware that simulation of static load test with CAPWAP (or DLT) does not include any long term effects like creep or long term settlements. This is why in almost all cases CAPWAP load-set curve is little higher than load-set curve from static load test, specially for for higher loads and toe bearing piles.

Also GOST is regulated only two out of six measurements with reducers provided by ASTM. By requirement of both standards of loading on pile is transferred by jack. But GOST does not consider that each jack needs to be provided by manometer if we use more than one jack. It is important for control of work of jack and to do correct test [Smolin at al 2013].
In other case sometimes reducers of axial displacement of pile showed undirected displacement and regarding requirement of GOST is not instructions.

Table 3. Principal differences between American Standard and Kazakhstan norms .

	GOST	ASTM
Parameter of experimental stand for test		
Distance between testing pile till anchoring pile	5d<L1>2.5m	3d<L1>1.5m
Distance between testing pile till	5d<L2>2.5m	L2<2m
	devices and equipment	
for loading	jack	jack with spherical prop
Measurement of load on top pile	manometer	manometer
	-	dynamometer (more 100 tc) fixed for each jack
Measurement of load on all length pile	-	tensometer
Measurement of axial displacement of top pile	transducer of axial displacement of cap	transducer of axial displacement of cap
	-	visual control
	-	optical instrumental control
Measurement of sway top pile	-	transducer of sway top pile
	-	optical control

ASTM showed new improvement in pile tests. Method of pile testing regarding Kazakhstan Standard in comparison with American Standard becomes obvious disadvantage.

Unfortunately, present Kazakhstan Standards are confined to application of modern pile technology and big difference between experimental bearing capacity obtained by static loading test (SLT) and design value obtained by Kazakhstan Standard indicates incomplete usage of modern pile technology. And so research of advanced pile technologies is very important for the feature Kazakhstan geotechnical development.

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