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Methods of testing pile by ASTM and GOST standards

Abstract. *This paper presented methodic of testing pile by ASTM D1143/D1143M-18 (USA) standard and GOST 5686-12 (Kazakhstan) standard. The methodic of testing piles by these standards have some differences. Discussion of using control equipment, technological features, advantages and disadvantages of aforementioned methodic might be important for understanding the different points. The papers include the results of static tests of piles by using two different standards. This full field scale piling tests were performed in problematical soil ground of construction sites of the new capital Astana (Kazakhstan).*
Keywords: *ASTM, standard, field test, soil, features, pile.*

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Introduction. Development of high-rise buildings and constructions in complex hydro-geological condition of some regions of Kazakhstan requires reliable design of foundation, this leads to improvement of the geotechnical Standards. Nowadays many international projects are realized in Kazakhstan, this demands to using international Standard, moreover, for realization unique project is required using leading foreign high-tech, economic, ecological and energy-efficient technology, including technology for pile installation, equipment for geological investigation [1].

Unfortunately, present Standards are confined application of modern technology of pile foundation installation, indicating incomplete usage of advanced technology. The results of research will have directed to modernization of the Kazakhstan Standards and oriented to advanced geotechnologies adaptation. Pile foundations are commonly used in Kazakhstan, especially in such regions as Astana, Karaganda, Atyrau, Aktau, Pavlodar, Kostanay and Kokshetau [2]. Field test is carried out in accordance with requirements GOST 5686-12 «Soils. Methods of the field tests with piles» [3]. Definitions of bearing capacity of the piles in accordance with requirements SNIP RK 5.01-03-2002 "Pile foundations" [4].

Methodologies of the field tests. In Kazakhstan dynamic test is carried out by using many types of pile driving machine. Before pile driving special marks through 1 m are painted on its surface along the whole length of the pile, but on last meter through each 0.1 m.

In process of the pile driving the numbers of blows is recording for each meter of pile penetration and last one meter through each 0.1 m. At the same time, it is necessary to fix height of the fall of the blowing part of hammer. Test pile driving terminated till designing refusals (See Figure 1).

For definition of the bearing capacities of piles it is required to use average refusal which is obtained during redriving of the piles after their «rest». The rest time depends on soil condition of site: for clayey soil 6 -10 days, for sandy and gravel soil up to 3 days. Redriving of test piles carry out two step-by-step guarantees at three and five blows of the hammer. Before beginning redriving on test piles attached measured tape, with lengths of 10 cm, divided by 1 mm. The control of the test pile penetration was conducted through theodolite [5].

Figure 1. Dynamic test of pie driving by machine Junttan PM-25

Static load test should be carry out for driving piles after the "rest" and for bored piles after achievements of the concrete strength 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 by 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 the 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.The criterion of conditional stabilization of pie 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 (see Figure 2). Reloading (unloading) conducted half stages of the loading. Carrying out of static test is shown in Figure 3. Data of static field tests drawing load – settlement diagrams are shown in Figure 4 [6].

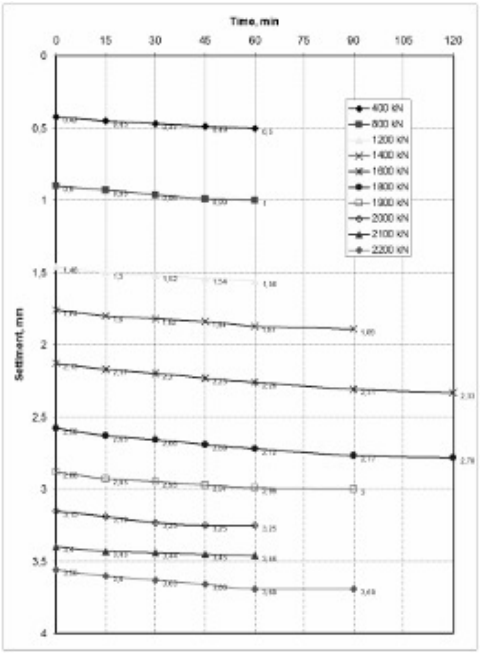

Figure 2. Criteria of conditional stabilization of pile

Figure 3. Static load test of bored pile performance

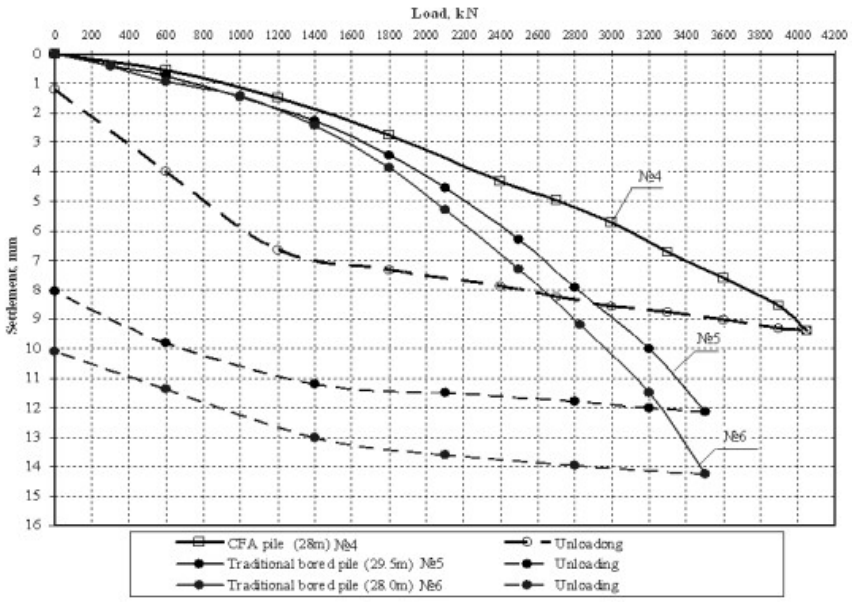

Figure 4. Diagrams of settlements S - loading P

Bearing capacity of the piles, Fu, by dynamic load test is defined as:

$$F_u = \frac{\eta AM}{2}\left|1 + \frac{4E_d}{\eta AS_a} \times \frac{m_1 + \varepsilon^2(m_2 + m_3)}{m_1 + m_2 + m_3} - 1\right| \quad (1)$$

where η=factor, dependent on concrete strength of the piles; A=area of the pile section; M=1 – factor, dependent on pile driving hammer's impact; E_d=effective energy of blows of the hammer, kNм, calculated:

$$E_d = G \times H \quad (2)$$

where G=weight of blowing part of the hammer, kN; H=drop height of blowing part of the hammer.

Static load involving settlement of the tested pile, which equals S and determined according to the below equation shall be taken as the particular value of the pile ultimate resistance to the pressing load defined as [1]:

$$S = \zeta S_{u,mt} \quad (3)$$

where ζ =coefficient for conversion factor of the limit value of mean settlement of foundation of the building or structure $S_{u,mt}$ into pile settlement obtained while static tests at conventional settlement stabilization; according to the requirements ζ =0.2 shall be taken as the coefficient value; $S_{u,mt}$ = S maximum permissible value of mean foundation settlement of the designed building or structure as stated either in the project statement or requirements SNIP RK 5.01-01-2002. "Soil grounds of the buildings". Dynamic and static load test on construction site in Astana by ASTM. now we analyzed dynamic and static load tests of driven steel h- pile on construction site of apartment "Embassy of the USA in Astana". Geology of construction site Embassy of the USA in Astana showed in Table 1 and Figure 5.

Table 1.

Geology of construction site Embassy of the USA in Astana

Element	E, кg/cm2	ν	γ, кg/cm3	c, кg/cm2	φ
Density Clay loam	210	0,35	0,00198	0,59	23
Semi-solid Clay	51	0,35	0,00189	0,27	19

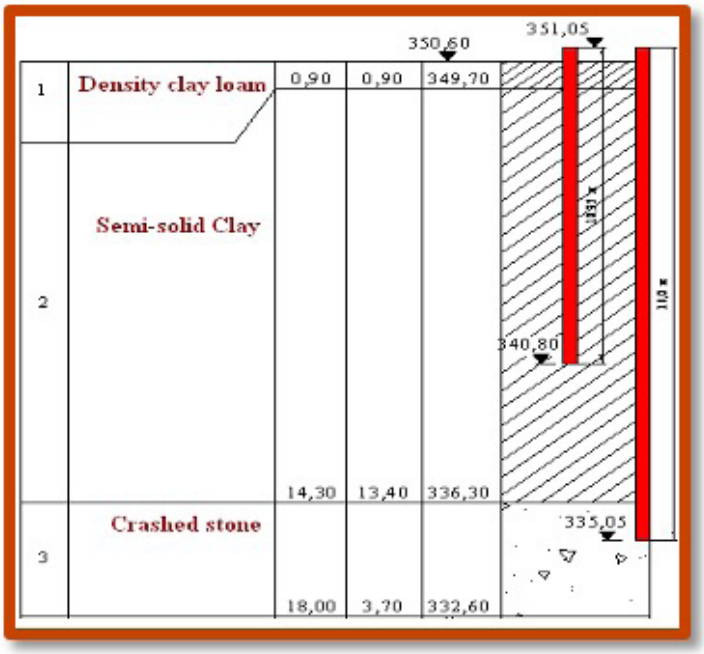

Figure 5. Geology of construction site Embassy of the USA in Astana

Results. Dynamic test:
Steel H - piles were driven according to design load, preliminary criteria of refusal:
- on 600 kN working loading, refusal of a pile should be equal 1.25 cm (25 cm/20 blows);
- on 400 kN working loading, refusal of a pile should be equal 1.67 cm (25 cm/15 blows).
Results of dynamic tests showed in Table 2 and Figure 6.

Table 2.

Results of the dynamic test

Number of stee H-piles	Embedded depth in soil, m	Design load, kN	Refusal of pile at driving, cm
LT-1	7.00	600	1.00
LT-2	9.00	600	1.09
LT-3	10.00	600	1.14
LT-7	8.25	600	1.00
LT-8	10.25	600	1.25
LT-9	9.25	600	1.25
LT-4	8.00	400	1.56
LT-5	8.25	400	1.47
LT-6	7.75	400	1.67

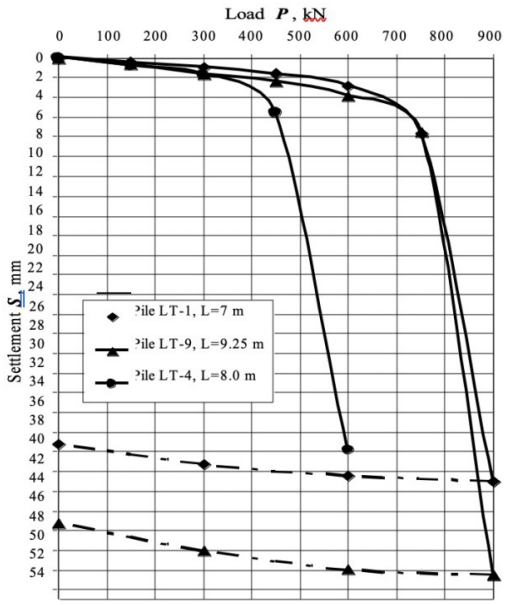

Figure 6. Results of dynamic load test

Static load test: The ultimate testing load for steel H-piles doubly exceed the allowable design load (according to the Standard ASTM D 1143-81): for 600kN design allowable loading - 1200kN ultimate tasting load, and for 400kN accordingly 800kN. Results of dynamic tests showed in Table 3 and Figure 7.

Table 3.

Results of static load test

Number of pile	Embedded depth, m	Design load, kN	Design load, kN	Settlement, mm	Applied load, kN
LT-1	7.00	600	1.00	43.03	900
LT-9	9.25	600	1.25	52.55	900
LT-4	8.00	400	1.56	39.88	600

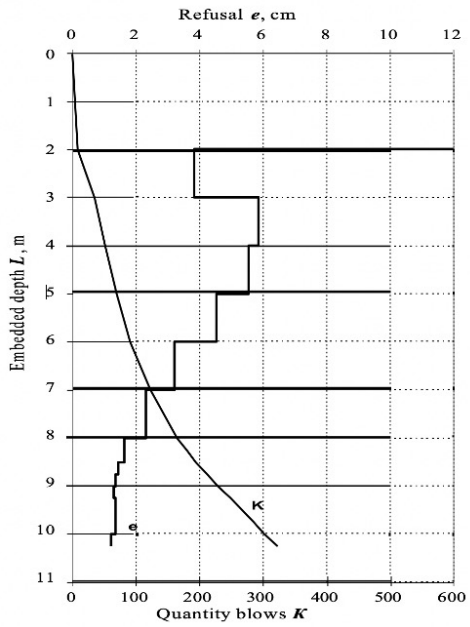

Figure 7. Results of static load test

After extension lengths of a steel H - piles by electric welding, were driven according to design load and preliminary criteria of refusal:

- for 600kN, refusal of 0.33 cm (25 cm/75 blows);
- for 400kN, refusal of 0.83 cm (25 cm/30 blows).
- and carried out static load tests again. Results of dynamic and static tests showed in Table 4.

Table 4.

Results of dynamic and static tests

Numberof pile	Embedd ed depth in soil, m	Design load, kN	Refus all of pile at drivin g, cm	Settlement, mm	Applied load,kN
LT-1	9.75	600	0.31	4.66	1200
LT-2	15.00	600	0.31	7.34	1200
LT-3	13.00	600	0.32	7.00	1200
LT-7	11.00	600	0.28	4.41	1200
LT-8	16.00	600	0.30	6.27	1200
LT-9	12.75	600	0.27	4.96	1200
LT-4	11.25	400	0.78	3.38	800
LT-5	11.25	400	0.74	2.17	800
LT-6	9.75	400	0.63	3.17	800

Conclusions. Since 1994 Kazakhstan Standard has not changed, ASTM standard was updated in 2007, and therefore took the latest developments in technology and technical terms and provides for the use of more modern equipment.

The analysis shows that the tests with ASTM make them more reliable and give detailed information about the process of testing and the results showed in Table 5.

The today's goal is to update the national standards, harmonize with international standards.

The introduction of innovations described will avoid making wrong results of test. Along with TC55 work Design Academy "KAZGOR" conducts research on the existing international experience of technical regulations to ensure the safe construction processes and products.

And members of these Committees registered that in practice tester sometimes has situations when make wrong design because in normative isn't detailed information.

Table 5.

Principal differences between American Standard and Kazakhstan norms

	GOST	ASTM
Parameter of experimental stand for test		
Distance between testing pile till anchoring pile [7]	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
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. The method of pile testing by Kazakhstan Standard in comparison with American Standard it is obvious disadvantage.

Unfortunately, present Kazakhstan Standards are confined 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 indicated incomplete usage of modern pile technology. And so, research of advanced pile technologies is very important for the future of Kazakhstan geotechnical development.

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ASTM және ГОСТ стандарттары бойынша қадаларды сынау әдістері

Аңдатпа. Бұл жұмыста ASTM d1143/D1143M-18 (АҚШ) стандарты және ГОСТ 5686-12 (Қазақстан) стандарты бойынша қадаларды сынау әдістемесі ұсынылған. Осы стандарттарға сәйкес қадаларды сынау әдістемесі кейбір айырмашылықтарға ие. Басқару жабдықтарын пайдалануды, технологиялық ерекшеліктерді, жоғарыда аталған техниканың артықшылықтары мен кемшіліктерін талқылау айырмашылық нүктелерін түсіну үшін маңызды болуы мүмкін. Жұмыста екі түрлі стандарттарды қолдана отырып, қадаларды статикалық сынаудың нәтижелері келтірілген. Қадалардың осы далалық заттай сынақтары Нұр-Сұлтан (Қазақстан) қаласының құрылыс алаңдарының проблемалы топырағында жүргізілді.

Түйін сөздер: ASTM, стандарт, далалық сынақтар, топырақ, ерекшеліктер, қадалар.

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Методы испытаний свай по стандартам ASTM и ГОСТ

Аннотация. В данной работе представлена методика испытания сваи по стандарту ASTM D1143/ D1143M-18 (США) и стандарту ГОСТ 5686-12 (Казахстан). Методика испытания свай по этим стандартам имеет некоторые отличия. Обсуждение использования управляющего оборудования, технологических особенностей, преимуществ и недостатков вышеупомянутой методики может быть важным для понимания различий. В работе представлены результаты статических испытаний свай с использованием двух различных стандартов. Эти натурные полевые испытания свай были проведены в проблемном грунтовом грунте строительных площадок новой столицы Астаны (Казахстан).

Ключевые слова: ASTM, стандарт, полевые испытания, грунт, особенности, свая.

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