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Analysis of interaction of boring CFA micro piles with problematic soil conditions Aksai, Kazakhstan

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ABSTRACT: This paper presents the complex analysis of diverse field loading tests of four with diameter 600 mm CFA bored piles. Four static compression pile (by ASTM D1143) loading tests were carried out on the construction site. Static loading tests applied load to a deep-foundation element gradually for measuring foundation settlement. This test is used to measure the axial deflection of a vertical deep foundation when loaded in static axial compression. This vertical compression pile maintained load test is usually carried out to ensure the structural and geotechnical soundness of the pile and also to predict settlement of other piles. Applied load and head movement are measured for static axial compression load tests. The load-settlement and the load-displacement curves were obtained from field tests. Comparison of bearing capacity of bored piles with different length in problematic soil conditions of West Kazakhstan were discussed in this paper. The analysis showed that the bearing capacity of bored piles with different lengths corresponds to the design requirements. These investigations are important for understanding of soil-pile interaction on problematical soft soils ground of Aksai, Kazakhstan.

1 INTRODUCTION

The Karachaganak field is one of the world's largest oil and gas condensate fields located in northwest Kazakhstan and covering an area of more than two hundred eighty square kilometers. The Karachaganak field is located in a remote and challenging working environment with the ambient temperature ranging from minus forty degrees Celsius in winter to plus forty degrees in summer. The field, the top of which is located at a depth of around three thousand five hundred meters, is some one thousand six hundred meter thick and very complex and unique. Karachaganak Field is a gas condensate field in Kazakhstan. It is located about twenty three kilometers east of Aksai (Aksai) in the northwest of Kazakhstan. The field was once a massive Permian and Carboniferous reef complex covering an area thirty by fifteen square kilometers. Karachaganak field was discovered in northwestern Kazakhstan by Uralskneftegas-geologia in 1979 and first produced by Karachaganak in 1984. The shareholder group of ENI-Agip, BG Group, Texaco, and Lukoil operates the field under a 40-yr production-sharing agreement that was signed with the Republic of Kazakhstan in November 1997 to optimize technical and economic recovery. In the field, 252 wells have been drilled, with 163 available for production. An ongoing workover program has restored previously declining production to historic maximum levels.

The current work aims at investigating the ability for the enhancement of clay using CFA piles. The development in bearing capacity has been determined based on field tests carried out including top down static loading tests and pull out load tests. Moreover, the current work com-peres the cost between using normal piles in site project and use improvement of soil by use CFA piles. The paper suggests a method to validate the enhancement in bearing capacity of clay improved with CFA piles.

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2 ENGINEERING-GEOLOGICAL CONDITIONS OF THE CONSTRUCTION SITE

In geological structures of a site of researches, take part (GOST 20276–99, 1999):

EGE-1: Loam-heavy, dusty, yellowish-brown, brown color, lumpy, weakly wet, from solid to semisolid consistence, setting;

EGE-2: Clay-light, brownish black, yellowish-brown and brown color, lumpy, weakly wet, from solid to semisolid plastic consistence, setting;

EGE-4: Clay-light, dusty, brown and light brown color, lumpy, weakly wet, from solid to tough plastic consistence;

EGE-5: Clay reddish-brown, dark brown color with black free deigns, solid weakly wet, from solid to tough plastic consistence;

EGE-6: Clay-light, dusty, greyish-brown, dun color with free designs of grey color, average density, weakly wet, wet, from semisolid to tough plastic;

EGE-7: Clay-light, dusty, dun, grey, dark grey color, average density, wet, tough plastic.

Results of physic-mechanical properties of soil the bases of construction site are resulted from top to down in Table 1 (Zhussupbekov *et.al* 2019).

Table 1. Standard and design values of physical and mechanical characteristics of soils.

	Soil Consistency g/cm^3	Specific cohsion MPa	Angle of internal friction, deg.	Modulus of deformation	De sign resistance, kPa
N EGE	ρ	c	ϕ	E	R_0
1	1.73	–	–	9.34	400
	1.96	0.006	20	4.4	200
2	1.77	–	–	7.39	400
	1.97	0.008	19	4.78	200
4	1.92	–	–	8.08	400
	2.03	0.015	19	7.10	250
5	1.94	0.029	17	7.59	250
	2.01	–	–	–	–
6	1.96	0.026	18	8.09	250
	2.01	–	–	–	–
7	1.98	0.020	19	8.33	250
	2.03	–	–	–	–

3 SOIL FIELD TEST BY PLATE LOAD TESTING

Plate Load Test is a field test for determining the ultimate bearing capacity of soil and the likely settlement under a given load. The Plate Load Test basically consists of loading a steel plate placed at the foundation level and recording the settlements corresponding to each load increment. The test load is gradually increased till the plate starts to sink at a rapid rate. The total value of load on the plate in such a stage divided by the area of the steel plate gives the value of the ultimate bearing capacity of soil. The ultimate bearing capacity of soil is divided by suitable factor of safety to arrive at the value of safe bearing capacity of soil. PLT tests by loading a plate with a diameter of 300 mm are made in accordance with requirement GOST20276 (1999) or ASTM D1194. The plate loading test (further PLT) was carried out in the workings at a depth of 1.2 m while maintaining the natural addition of soil, with a flat die 300 mm in diameter, to determine the elastic modulus of deformation (see Figure 1).

Testing with a flat PLT consisted in the fact that the stamp was placed on the bottom of the pit, on the previously cleaned and leveled surface of the ground, after which a step-by-step loading was performed on the stamp. The subsequent stage of loading was carried out after the decay of the deposit from the previous loading. As a support, beams fixed on both sides on the anchor piles were used. Totally three tests one test in Plate Load Test 1 (further PLT–1), second test in Plate Load Test 2 (further PLT–2) a depth of 1.2 m had been made. The load intensity and settlement observation of the plate load test are plotted. The figure shown below shows a set of typical load settlement curves. Figure 1 shown the results the pressure-settlement diagrams of Plate load tests of PLT–1, PLT–2 and PLT–3.

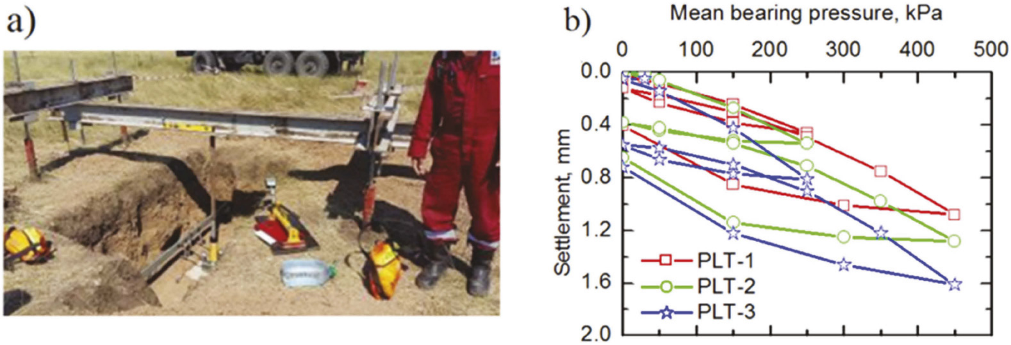

Figure 1. Plate load test: (a) Field test for determining the bearing capacity of the soil; (b) load-settlement curve (PLT–1, PLT–2 and PLT–3).

Modulus of deformation of soils in PLT–1 – 108,8MPa, PLT–2 – 86,1 MPa and PLT–3 – 61,7 MPa depth of 1.2 m.

4 STATIC LOADING PILE TEST (SLT BY ASTM D1143)

The CFA construction sequence is comprised of five stages in Figure 2:

– Stage 1. The digging tip of the auger is fitted with an expendable ca);
– Stage 2. The auger is drilled into the ground to the required depth;
– Stage 3. Concrete is pumped through the hollow stem, blowing off the expendable cap under pressure;
– Stage 4. Maintaining positive concrete pressure, the auger is withdrawn all the way to the surface;
– Stage 5. Reinforcement is placed into the pile up to the required depth.

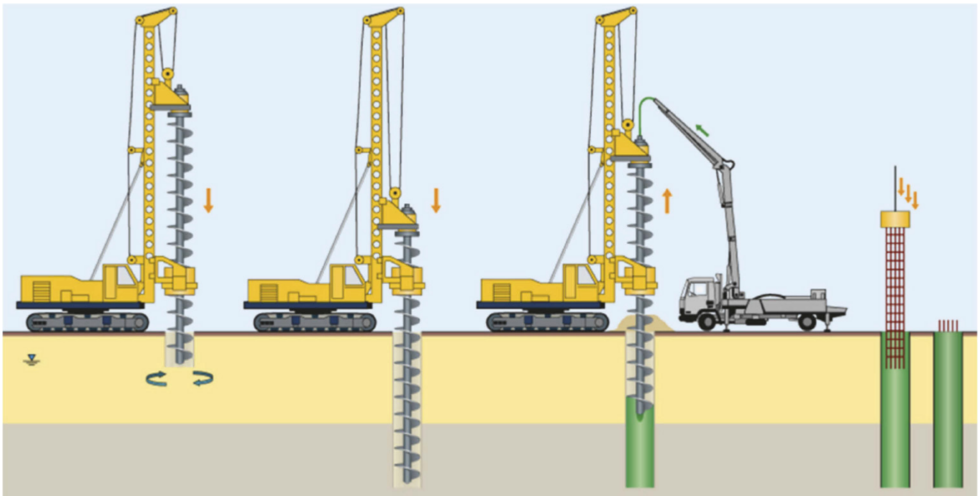

Figure 2. Technological process of CFA piles.

Bored piles, which have diameter of 600 mm and from depths 15.53 to 21.85 m have been executed at the Caspian Sea for more shipments platforms construction site (Zhussupbekov *et.al* 2016).

Static Loading Pile Test (further SLT) one of the more reliable field tests in analyzing pile bearing capacity. SLTs carried out for four piles on the construction site.

a) b)

Figure 3. Field pile test by SLT (ASTM): (a) anchors pile system and (b) loading platform system.

It is seen from Figure 4 that the load-settlement curves of four piles SLT-1, SLT-2, SLT-3 and SLT-4 are almost identical, having an ultimate shaft capacity of 1050 kN for SLT-3 and SLT-4, and pile number SLT-2 to loading - 1310 kN and pile number SLT-1 to loading - 1975kN (Zhussupbekov & Omarov, 2016).

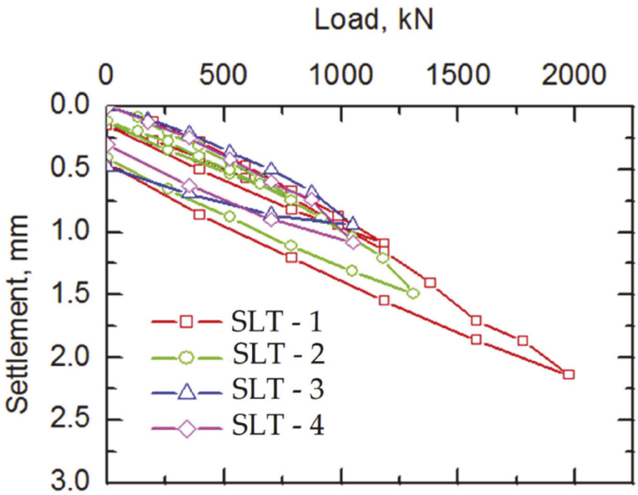

Figure 4. Load-settlement curves of four piles.

Pile static loading tests (top down) were performed on bored piles numbers: SLT-1, SLT-2, SLT-3 and SLT-4, which are with depth from 15.53 and 21.85. In SLT testing, the test load on the pile is specified for one and two cycles (one 1050 kN (for SLT-3,-4) and two cycles from 786 kN to 1310 kN (for SLT-2) and from 1185kN to1975kN (for SLT-1), respectively). Loading and unloading was carried out in the following sequence (for SLT-1): 0, 25, 50, 75, 100, 125, 150, 100, 50, 0, 25, 50, 100, 125, 150, 175, 200, 225, 250, 200, 150, 100, 50 and 0% of design. In the first cycle, the experimental pile was loaded to 150% of the design value (to 1185 kN); during the second cycle, to 200% (maximal to 1975 kN). The hold time while loading was 60 min; while unloading −15 min. It took 300 min, respectively, to attain peak load (ASTM D1143/D1143M – 07, 2013). Table 2 presents a comparative analysis of the bearing capacity of piles, obtained by different method in this research (Zhussupbekov *et.al* 2016).

Table 2. Results of field piling static loading tests (top down load).

№	Pile numbers	Pile length, m	pile Diameter, mm	Overpressure loads on the pile, kN	Settlement at maximum pile load, mm
1	SLT-1	20.50	600	1975	2.14
2	SLT-2	15.53	600	1310	1.48
3	SLT-3	21.85	600	1050	0.94
4	SLT-4	21.72	600	1050	1.08

5 CONCLUSION

The results of the axial compression loading tests performed in soft to firm or stiff clays demonstrated the suitability of CFA bored pile foundations. The results of the loading testing program confirmed that the CFA bored pile is a viable deep pile foundation option for construction site Oil and Gas in remote areas Kazakhstan and demonstrated their advantages.

The results of the full-scale load tests are also used to validate the theoretical model used for CFA technology bored pile design installed in soft and problematical soils of Kazakhstan.

The bearing capacity of CFA technology boring piles according to the results of shown Table 2 amounted to be maximal load to (top down load, L) 1975kN, settlement (S) from 0.94 mm to 2.14 mm. These investigations are important for understanding of behavior of piles on problematical soil ground of Kazakhstan.

6 FUNDING

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