The experience in applying of static load and O-cell pile testing geotechnologies in problematical soil conditions of Astana

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ABSTRACT

The symbol of the exhibition EXPO-2017 will be the Kazakhstan platform itself made in the sphere form several floors high with 24000 m² in total. The symbol of the exhibition is located in the center of the exhibition village. It is surrounded by international, thematic and enterprise platforms.

The results and comparing of soil tests of the piles for following methods: Vertical static test Static Load Test (hereinafter SLT) and the Bi-Directional Static Load Test (hereinafter BDSLT). Experienced bored piles with a length of 31.5 m, diameter 1000 mm. Bi-directional static load tests and Static load tests carried out in accordance with ASTM D1143.

The method proposed by George Osterberg, allows to simultaneously determining the estimated soil resistance under the lower end of piles and on its lateral surface. Feature of O-cell test is that the load is applied not on the pile head, and the body of the pile, where is a jack (power cell), which works in two directions. Power cell (O-Cell) shares the experimental pile into two parts: upper (upper test item) and the bottom (lower test item).

The target of this tests was obtaining of bearing capacity of piles on problematical soils ground of Expo 2017 (Astana, Kazakhstan).

Keywords: Bored piles, static load test, the load-settlement, Osterberg or O-cell testing

1 INTRODUCTION

For testing deep foundations on site construction of EXPO-2017 (Fig. 1) in Astana (Kazakhstan) were static tests by the vertical pressing loading «from top to down» as well as the static tests were carried out using the Osterberg method (O-cell test).

Static tests were subjected to three bored piles, one of which was tested by a method of SLT (No. of pile 166) and two by O-cell method (PTP-1 and PTP-2). The location of the experimental piles is shown in Figure 1.

Experienced bored piles with a length of 31.5 m, diameter 1000 mm. Bi-directional static load tests and static load tests carried out in accordance with ASTM D1143.

Feature of O-cell test is that the load is applied not on the pile head, and the body of the pile, where is a jack (power cell), which works in two directions. Power cell (O-cell) shares the experimental pile into two parts: upper (upper test item) and the bottom (lower test item). Hydraulic jack is installed at a depth of 2/3 the length of the piles-16.8 m.

Fig. 1. Experimental site of EXPO-2017 for testing.
2 THE RESULTS OF THE GEOTECHNICAL SURVEY OF THE SITE

Typical geotechnical conditions of the Expo-2017 construction site which mentioned before are represented by the following soils:

Soil 1 – loam with detritus is covered by top soil and fill-up soil in the depth of 0.20-0.40 m. The thickness of layer varies from 3.6 to 8.1 m. On the field description loam is brown, carbonated, and with middle coarse sand band which is thickness equal to 5 cm and with 5-10 cm thickness loamy sand layer.

Soil 2 – middle coarse sand is brown, with loamy soil which is thickness equal to 5-10 cm and water-saturated. The middle coarse sand thickness is 0.60-4.50 m.

Soil 3 – Coarse sand thickness is 1.0-3.9 m. Coarse sand is described by semi-gravel, color is brown, and with middle coarse sand band which thickness equal to 5-10 cm, water-saturated and include 10 percent gravel fragment.

Soil 4 – loam is deep-brown and mahogany color. And include debris and detritus up to 10 percent.

Geotechnical condition of construction site and details of piles are shown in Fig. 2.

3 STATIC TESTS OF PILES BY SLT METHOD

Vertical static tests of piles by SLT method is one of the most reliable field test methods of soils for analysis of the bearing capacity of piles (Fig. 3).

The increment of the load was 25%. The sequence of application of the force is as follows: 25, 50, 75, 100, 50, 0, 25, 50, 75, 100, 125, 150, 175, 200, 150, 100, 50, 0% of the project (6000 kN). In the first cycle of experimental pile up to 100% of the project pressurization, in the second cycle load up to 200%. The exposure time of the intermediate stages of loading amounted to 30 min, unloading -20 min. Exposure time of peak load amounted to 120 min and 240 min respectively.

Experienced bored piles with a length of 31.5 m, diameter 1000 mm. Static load test carried out in accordance with ASTM D1143. Load test on pile amounted to 600 m and 1200 tons. Tests carried out after reaching the strength of the concrete piles more than 80%.

Fig. 3. Static tests of piles by SLT method.

Fig. 4 presents the results of the SLT method. The first test cycle up to 6000 kN load represented by the red line, with full draught amounted to 2.09 mm. The second cycle of up to 1200 kN load – blue line, full of sediment was 10.51 mm.

Fig. 4. Schedule of load-settlement by SLT method of pile No. 166 (load 6000kN and 12000kN).

4 O-CELL TEST OR STATIC TEST OF SOILS BY PILES BY BI-DIRECTED LOAD

The method proposed by George Osterberg, allows to simultaneously determining the estimated soil resistance under the lower end of piles and on its lateral surface.

Feature of O-cell test is that the load is applied not on the pile head, and the body of the pile, where is a jack (power cell), which works in two directions. Power O-cell shares the experimental pile into two parts: upper test item and the bottom (lower test item). Power
cell is a calibrated system of hydraulic jacks that are combined into a single module. Hydraulic jack is installed at a depth of 2/3 the length of the piles-16.8 m (Fig. 5). The power cell is connected using hydraulic hoses with the hydraulic pump located on the surface of the soil.

Testing of soils by piles by Osterberg method (method of immersed Jack) allows carrying out tests to determine the bearing capacity, as separate engineering-geological elements and in the whole entire side surface of the pile and/or the heel.

Before the tests in the body of the experimental piles were installed 10 strain gauges sensors, whose layout is shown in Fig. 4. The strain gauges are connected to the data logger is presented in Fig. 5 (SG1 to SG10).

Testing by O-cell method is shown in Fig. 6.

Fig. 5. Scheme of O-cell testing:
a) Schematic Diagram of Pile Layout; b) O-cell test instrumentation.

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Fig. 6. Test pile static load by O-cell method:
a) Experimental pile and fiducially system; b) Displacement sensors; c) Hydraulic system.

Fig. 7 presents the results of t strain gauges. Fig. 7 presents the distribution of the load along the length of the piles. The graph shows that even at maximum load, the pile is kept by lateral resistance of the soil. Only a small portion of the load is on the edge of the pile

Pile of PTP-1 the pile section above the jack, the shear distribution indicated an increase in unit skin friction from 76kN/m² to 481kN/m² at 200% of the working load. For the pile section below the jack, the

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Fig. 7. Total design load distribution of PTP-1 and PTP-2 piles by O-cell method.

Pile of PTP-1 the pile section above the jack, the shear distribution indicated an increase in unit skin friction from 76kN/m² to 481kN/m² at 200% of the working load. For the pile section below the jack, the
shear distribution indicated an increase in unit skin friction from 190kN/m² to 458kN/m² at 200% of the working load.

Pile of PTP-2 the pile the pile section above the jack, the shear distribution indicated an increase in unit skin friction from 83kN/m² to 477kN/m² at 200% of the working load. For the pile section below the jack, the shear distribution indicated an increase in unit skin friction from 207kN/m² to 437kN/m² at 200% of the working load.

Unlike SLT method, O-cell testing can yield two dependences «load-settlement»: one curve characterizes the resistance of the pile below the bottom end, the second – on its lateral surface. Using these two curves you can get an equivalent curve «load-settlement», which is analogous to the SLT curve.

The O-cell test results are presented in Fig. 8.

Fig. 9 shows the comparison of the results of piles test by O-cell method (the equivalent curve).

5 CONCLUSION

Field O-cell load test was carried out and results of field test were analyzed for the first time in Astana, Kazakhstan. The method of O-cell has been studied and described advantages of using O-cell load test for large diameter pile foundations.

The tests results are follows: At the maximum work test loading of 100% (14500kN), the maximum displacement of the pile are PTP-1 – 7.30 mm, and at the maximum work loading of 200% (29000kN), displacement of the pile are PTP-1 – 18.35 mm.

Following results are obtained from the mentioned static load test (top download):
- the maximum settlement up to 6000 kN is 2.09 mm;
- the maximum settlement up to 12000 kN is 10.51 mm;
- the residual settlement after unloading to zero is 0.32 mm.

The O-cell testing method provides some important advantages. There is no structural loading system at the ground surface. Load can be applied at or very close to the pile tip for measurement of base resistance. In conventional top load testing, most or all of the shaft resistance must be mobilized before there is significant load transfer to the tip.

The O-cell test method offers a number of potential advantages versus the conventional testing of bored piles: economy, possibility of high load application.

The development of bidirectional load on high bearing capacity of the piles gives engineers a new powerful tool for assessing the interaction of the piles with the subsoil. Finally this method is saves funds and time, because of no necessity to use of anchoring system.

In spite of benefits of O-cell tests there are some limitations. The applied method is mainly used for bored piles. The principle disadvantage is: adjustable jack and transducer for measuring displacements have
to be pre-installed before testing and after testing they remain in the pile.

Along with the disadvantages, the major advantage of the O-cell is that it allow to determine pile tip and shaft resistance both, which is has special value for the analysis and evaluation of bearing capacity of piles of a large diameter.

REFERENCES