Comparison of results of series pile load test in accordance with ASTM and Kazakhstan standards

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ABSTRACT

The results of series field test on piles on strategic oil and gas site in Kazakhstan are presented in this paper. The test include: static load test in accordance with ASTM and Kazakhstan standards (GOST), dynamic load test in accordance with GOST and pile driving analyzer (PDA) in accordance with ASTM. The difference of standards procedures and test results is presented.

Keywords:

1 INTRODUCTION

Field load tests on piles were performed on oil and gas construction site of Kazakhstan Republic: Integrated petrochemical complex and infrastructure (IPCI) Project. The tested areas and tested pile positions is presented on Figure 1. The tests had been made by the specialists of KGS, Llp form April to August of 2014.

Tested bored piles installed by technology of CFA (Bauer) and Kelly (Soilmec). For bored piles loading the anchor-supporting stand had been used. Reaction forces from the load had been perceived by 20 m length anchor piles.

For tested load application was used hydraulic jack DG500G250 and DG200P150 (500 and 200 tons capacity respectively). The pile movement (settlement) fixed by deflectometer 6PAO. During the tests independent reference beams and deflectometer had been protected from the effects of wind, temperature, and other negative impacts. Pressure gauges MP63 per 1000 atm. had been used to control the pressure (load). To overpressure and load increment pumping station GNR 8080 had been used.

Dynamic test of piles were performed for driven piles. Standard dynamic tests conducted in accordance with the requirements in [1], and PDA dynamic test in accordance with [2, 3, 4].

PDA is the pile testing process, which is an alternative to static load test. The final result of PDA is pile static capacity of tested pile at the time of testing.

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Fig. 1. Tested areas and tested pile positions

Generally 12 driven piles T414-1 – T414-12 and 9 bored piles T622-1 – T622-9 had been tested. Description of pile marks: T - tested pile, 4 - diameter of bored pile or width of driven pile (400 mm), 14 - length of pile 14 m, 1 - sequence number. The series of pile test include: compression static load test in accordance with ASTM and Kazakhstan standards (GOST), dynamic load test in accordance with GOST and pile driving analyzer (PDA) in accordance with ASTM.

Tested piles were drove by driving machine JUNTTAN PM25L with hydraulic hammer NNK7A, weight of hammer is 7 ton and hammer helmet of 990 kg. Between pile head and hammer helmet, pile cushion was used: plywood with thickness >15 cm. The load platform had been used for driven pile static load test (Figure 2). Reaction forces from the load had been perceived by calibration blocks (weighing 2.4 tons), as well as piles of C14-40 (weighing 5.6 tons).

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Static load capacity of the pilot is determined on the basis of pile measurements performed with PDA during pile driving and analysis with a computer program CAPWAP. The result of CAPWAP analysis is static load capacity of the tip and skin of measured pile.

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On the tested pile a pair of accelerometers and at least a pair of strain transducers are attached at least two pile diameters below pile head. Sensors performs all the necessary signal during driving for each hammer blow: force at the pile head \( F_{\text{measured}}(t) \), pile head movement velocity \( v_{\text{measured}}(t) \) as a function of time, down and up traveling wave and so on. All data is recorded, so it could be re-analysed.

2 GEOLOGICAL CONDITION OF SITE

Hydro-geological section of site (description of soil layers) is presented in Figure 3.

1- Sandy loam, gray, stratum of sand, clay with carbonate inclusion;
2- Clay, brown with carbonate inclusion;
3- Clay, gray stratum of sand, inclusion of gypsum;
4- Sandy load, gray with carbonate inclusion, inclusion of gypsum;
5- Sand, brown, fine with carbonate inclusion, dense;
5a- Sand, brown, fine with carbonate and clay inclusion, dense;
6- Clay, gray with sand, gypsum and carbonate inclusions;
7- Sandy loam, dark gray with cockle-shell and sand inclusion;
8- Sand, gray, fine, dense;
9. Clay, gray with stratum of sand, sandy-loam and loam:

10. Sand, gray, fine, with cockle-shell inclusion, dense.

3 RESULTS OF TESTS

The results of tests are presented in tables and diagrams. The comparison of the results of the static load tests by ASTM-CLT and dynamic tests by PDA (for driven piles) are presented in Figure 4. All curves PDA test are presented by double broken line. Nevertheless, the initial elastic-plastic part of the curves has quite high convergence with static. Then the curves have sharp decline, which is typical slump.

Bearing capacity of pile (static load test) in accordance with Kazakhstan standards is determined in the range of ultimate settlement criteria 16-24 mm. In case of PDA bearing capacity definition the fact of «in those hydro-geotechnical conditions, only the initial part of the curves are more or less close to static curves» should be considered.

Comparison of bearing capacity by results of static tests (ASTM) and dynamic tests by PDA method and GOST is presents in Table 3.

<table>
<thead>
<tr>
<th>Marking</th>
<th>Static load test by ASTM (CLT)</th>
<th>Dynamic load test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T414-1</td>
<td>1570 kN</td>
<td>PDA 1490 kN</td>
</tr>
<tr>
<td>T414-2</td>
<td>1470 kN</td>
<td>3 blows 598 kN</td>
</tr>
<tr>
<td>T414-4</td>
<td>1765 kN</td>
<td>5 blows 628 kN</td>
</tr>
<tr>
<td>T414-5</td>
<td>1675 kN</td>
<td>3 blows 863 kN</td>
</tr>
<tr>
<td>T414-7</td>
<td>1715 kN</td>
<td>5 blows 569 kN</td>
</tr>
<tr>
<td>T414-8</td>
<td>1450 kN</td>
<td>3 blows 834 kN</td>
</tr>
<tr>
<td>T414-10</td>
<td>1905 kN</td>
<td>5 blows 540 kN</td>
</tr>
</tbody>
</table>

During the GOST test performance time interval increased with each load increments, the last stages (total load applied) time interval came up to 10 hours of observation. Limitations of time interval in case of ASTM test lead to slightly low results compared to GOST.

Relatively high total load maintains (24 hours) in case of CLT by ASTM lead to comparability with GOST result.

Time interval of intermediate and peak steps of QLT accepted - 10 min. Immediate unloading maintained for 5 min. As a result the curves showed a difference of soil resistance and pile settlement both.

If the time interval of the last stage to increase at least to 1 hour, the difference of ultimate settlement would have been much more essential.

The quantitative evaluation of test series is presents in Figure 6. Figure 6b shows comparison of bearing capacities within allowable criteria of settlement of 16-24 mm. Quantitatively, dependence is expressed by \( y=ax \); distinction of argument \( a \) from 1.0 had evidence of less convergence of compared data.

Fig. 4. Results of ASTM static load test and PDA

Fig. 5. Comparison GOST and ASTM test results

Table 3. Comparison of piles bearing capacities

Fig. 6. Comparison of bearing capacities by ASTM (CLT) and GOST

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Fig. 6. Comparison of test results

4 CONCLUSION

1. A series of field load tests of soil by piles loading had been made by following methods: PDA, GOST and ASTM. The main technological features of procedure of methods are presented (Table 3 and 4).
2. PDA results showed a higher convergence with results of static tests (in accordance with GOST) than the results of standard GOST dynamic test. It should be noted that a close relationship PDA and GOST (static) results is observed at the initial stage of piles loading.
3. Comparison results of static tests in accordance with GOST and ASTM (by different methods) showed that the curves are directly dependent on the load maintains (time intervals).
4. The most distant from the static test results showed dynamic tests according to GOST. It should be noted that the direct method of energy determining (visual evaluation of the height of the hammer fall) is not always accurate, as part of the energy can be expended (absorbed) by pile cushion (mostly wooden).

The author expresses his deep gratitude to the leadership and specialists of KGS, Llp for the organization and helps during the tests performance.

REFERENCES

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