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# Analysis of complex tests on precast concrete joint pile

## Analyse des essais complexes sur les pieux en béton préfabriqué

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ABSTRACT: The article presents the results of the static and dynamic tests of soil by precast concrete joint pile with a total length of 27.5 m No. k3 at the construction site of Cargo offloading facilities (Prorva, Atyrau region). It is composed of two segments with cross-section 40cm x 40cm: the bottom segment with length of 16.0 m (KP16-40) and upper segment length: 11.5 m (KP11.5-40). Dynamic tests were conducted by PDA (Pile Driving Analyzer – Model PAX) and traditional methods also static test by the requirements of the American Society for Testing Materials (ASTM). According to comparison of the test results Dynamic test by PDA is more effective and faster for the soil of the North East Caspian Sea.

## 1 INTRODUCTION.

Field testing of the soil by pile were carried out at the site construction of Cargo Offloading Facilities (hereinafter – COF) of Cargo transportation route of the North-East part of the Caspian Sea. Facilities designed for offloading cargo handling bulky and general cargo in the north-east coast of the Caspian Sea near the Prorva oilfield delivered by river / sea transport.
Dynamic tests were conducted by PDA (Pile Dynamic Analyzer) and traditional methods, also static test by the requirements of the American Society for Testing Materials (Standard Test Methods for Deep Foundations Under Static Axial Compressive Load).
Static and dynamic tests were carried out on precast concrete joint pile with a total length of 27.5 m. It is composed of two segments with cross-section 40 cm x 40 cm: the bottom segment with length of 16.0 m and upper segment length: 11.5 m. For driving bottom segment between pile head and hammer helmet pile cushion was used wood with thickness 10 cm and nylon driving plate (EMECE) with yield stress 72 MPa, thickness 6 cm. For driving upper segment was used wood with thickness 20 cm. Also pile is applied by corrosion protection material (bituminous) and marked every 0.25 m (see Figure 1).

Figure 1. Installation of precast concrete joint pile

The purpose of testing is estimation of the bearing capacity and comparison of the results of different tests by one pile.

### 1.1 *Engineering-geological structure of the construction site*

The project area is situated on the Northern Caspian Shelf. At present the North Caspian Sea has a limited water depth (maximum 5 to 8 m). The water level in the Caspian Sea depends on a balance between the inflow of river water and evaporation. Table 1 shows engineering-geological structure of the construction site. Eleven engineering-geological elements (units) are identified based on the geological setting and the borehole logs (Geotechnical Interpretation Report).

Table 1. Engineering-geological elements

| unit | geological formation | soil type | level top [m+BD] | layer thickness |
|---|---|---|---|---|
| EGE-1 (man-made) | technigenic | FILL: SAND, clayey, calcareous | -25.5 | 2.0 |
| EGE-2 ($mQ_4nk$) | new Caspian | SILT, slightly organic, calcareous | -27.5 | 0.5 |
| EGE-3 ($mQ_4nk$) | new Caspian | SAND, silty, calcareous | -28.0 | 4.0 |
| EGE-7 ($mQ_3hv$) | late Khvalynian | CLAY, silty, calcareous | -32.0 | 4.0 |
| EGE-8 ($mQ_3hv$) | inter Khvalynian | SAND, silty, calcareous | -36.0 | 4.0 |
| EGE-9 ($mQ_3hv$) | early Khvalynian | CLAY, sandy, calcareous | -40.0 | 5.0 |
| EGE-10 ($mQ_3hv$) | early Khvalynian | CLAY, silty, calcareous | -45.0 | 5.0 |
| EGE-11 ($mQ_3hv$) | early Khvalynian | MARL / LIMESTONE | -50.0 | 2.0 |

### 1.2 *Static compression load test (SCLT)*

SCLT was performed on precast concrete joint pile No. k3, which driving in COF Area with depth 26.90, from ground level Baltic datum -25,609 m and pre-augering with auger dia. 330 m, depth 11.40 m before driving.
Testing platform (see Figure 2) presented itself system from steel, which consists of metallic beam and 2 platforms located on equidistant distances from the center main beams.

Figure 2. Testing platform for static compression load test

For platforms used concrete blocks, which pack on one platform by total weight 200-205 tons. The vertical load creating with hydraulic jack DG500G250. The pressure in the jack was creating with using electro-hydraulic pump NER-1,6A40T1, with manual distributor. The system was supplied with software for acquisition, display and printing of results (see Figure 3).

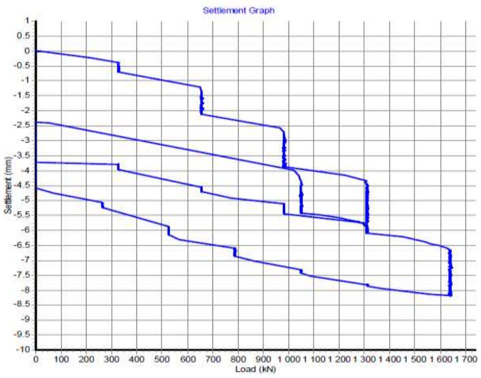


Figure 3. Settlement graph from the Static load test program

## 1.3 *Dynamic Test with PDA*

Pile Dynamic Test was performed on joint concrete piles No. k3. Pile was tested with PDA (Pile Driving Analyzer – Model PAX) using hammer JUNTTAN PM25LC with a hydraulic hammer HHK-9A of 9 tons of weight and a head-cap of 990 kg. 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 (see Figure 4).

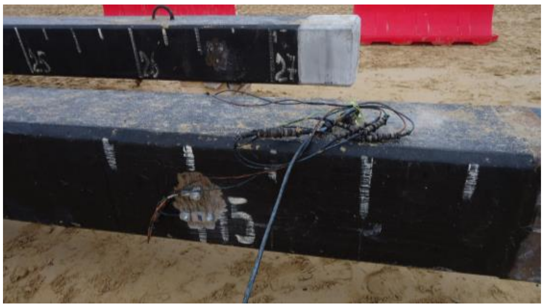

Figure 4. Prepared piles for Dynamic test by PDA

Sensors are connected to the Pile Driving Analyzer that internally performs all the necessary signal conditioning and processing to obtain output results during driving for each hammer blow and immediate screen display of measured force at the pile head ($F_{measured}$(t)) and pile head movement velocity ($v_{measured}$(t)) as a function of time.

After the execution of field part of dynamic test, selected blow data are analyzed in the computer program PDIPLOT2 Ver 2016.1.56.3 - Case Method & iCAP® Results (see Figure 5).

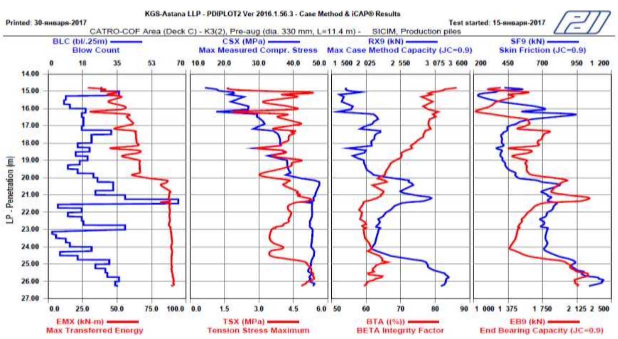


Figure 5. Analyzed data by graph from PDIPLOT2

## 1.3 *Traditional Dynamic Load Test (TDLT)*

Traditional Pile Dynamic Test was performed on joint concrete pile No. k3 during the driving process by using hammer JUNTTAN PM25LC with a hydraulic hammer HHK-9A of 9 tons of weight and a head-cap of 990 kg. During the pile driving we counted blows every 0.25 m. The analysis of blow count (see Figure 6) confirm engineering-geological structure of site.

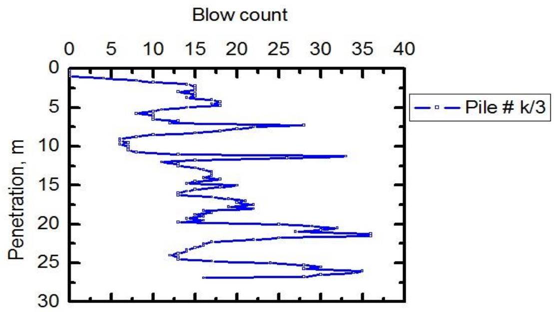


Figure 6. The result of pile driving k3.

It is common practice to use the following driving equation to estimate the driving resistance (ultimate pile capacity), Fu, in Kazakhstan (see Eq.1):

$$F_u = \frac{\eta AM}{2}\left[\sqrt{1+\frac{4E_d}{\eta A s_a}\times\frac{m_1+E^2(m_2+m_3)}{m_1+m_2+m_3}}-1\right] = 1236\,kN \quad (1)$$

## 1.4 *Calculation of bearing capacity*

Pile bearing capacity $F_d$ is determined by formula 7.8 from Interstate rules and regulations («Foundation design») (see Eq.2):

$$F_d = \gamma_c(\gamma_{cR} RA + u\sum \gamma_{cf} f_i h_i) = 1867\,kN \quad (2)$$

## 1.5 *Results of analysis of bearing capacity estimation*

Table 2 shows the results of static and dynamic tests also calculation by Interstate rules and regulations.

Table 2. Analysis of complex tests and calculation

| Type of test | SF | Bearing capacity | Allowable bearing capacity | % |
|---|---|---|---|---|
| SCLT | 1.2 | 1639 kN | 1366 kN | 100 |
| PDA | 1.4 | 1734 kN | 1239 kN | 91 |
| Analytical | 1.4 | 1867 kN | 1334 kN | 98 |
| TDLT | 1.4 | 1236 kN | 883 kN | 64 |

# 2 CONCLUSION

According to analysis of the results and calculation we can see that results of SCLT, PDA tests and analytical methods are similar than results of traditional dynamic tests. So we can use SCLT by requirements of ASTM and dynamic test by PDA.

From economical aspect we can use PDA for obtaining of bearing capacity of piles, because SCLT more expensive and time consuming than PDA test.

# 3 REFERENCES (TNR 8)


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