Smart Geotechnics for Smart Societies – Zhussupbekov, Sarsembayeva & Kaliakin (Eds)

Analysis of the results of field tests and numerical modeling to determine the settlement of piles in astana city

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ABSTRACT: A comparative analysis of the results of field tests and numerical modeling to determine the bearing capacity and settlement of a driven piles at medical facilitie at Astana are presented. The aim of the study was to carry out a comparative analysis of the results of numerical modeling and static tests in order to identify the difference in settlement of test pile under the design load. The results of settlement of the pile, determined by numerical modeling, is slightly lower than from static tests, with a difference in results being in 7%.

1 INTRODUCTION

An 800-bed Astana Medical University Hospital is being constructed on the right bank of the Esil River in the city of Astana, Kazakhstan. The total area of the hospital will be 140 thousand square meters. It will house a consultative and diagnostic center, round-the-clock and day facilities with 800 and 110 beds, respectively. Figure 1 shows an architectural rendering of the hospital complex.

Figure 1. Architectural rendering of hospital complex in Astana, Kazakhstan.

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2 GEOLOGICAL AND GROUND CONDITION OF CONSTRUCTION SITE

At the time of the geologic survey, the building site was free of any previous development. A total of 22 exploratory borings were made at the site.

In all of the borings, the topmost soil layer was found to consist of dark brown top soil. The thickness of this layer ranged from 0.5 to 3.6 m.

In all 22 borings, the top soil was underlain by a layer of saturated, light brown loam with clay seams up to 20 cm in thickness. The consistency of the loam varied between hard to soft-plastic. The thickness of this layer ranged from 0.0 to 7.5 m.

In 5 borings, a layer of saturated, brown sandy loam of medium density was next encountered. The thickness of this later ranged from 2.9 to 4.6 m.

In 13 of the borings, a layer of saturated, grey fine sand was next encountered. The thickness of this layer ranged from 1.0 to 12.0 m.

In 19 of the borings, a layer of saturated, light brown gravelly sand was next detected at a depth of approximately 9.8 m. the thickness of this layer ranged from 0.6 to 5.2 m.

In 12 of the borings, the gravelly sand was underlain by a layer of saturated clayet loam that was violet in color. The thickness of this layer ranged from 9.5 to 18.0 m.

Table 1 summarizes the values of geotechnical parameters that were determined from the results of laboratory tests performed on undisturbed samples taken from the boreholes in conjunction with statistical analysis of test results.

Table 1. Summary of parameter values for soils at astana medical facility site.

Soil type	C (kPa)	φ (degrees)	E (MPa)
(EGE-1) Topsoil	–	–	–
(EGE-2) Loam	17.0	13.0	5.0
(EGE-3) Sandy loam	19.0	27.0	6.5
(EGE-4) Fine sand	1.0	33.0	27.0
(EGE-5) Gravelly sand	1.0	38.0	35.0
(EGE-6) Loam	38.0	11.7	12.2

Figure 2 shows an idealized soil profile at the site of the Astana medical facility.

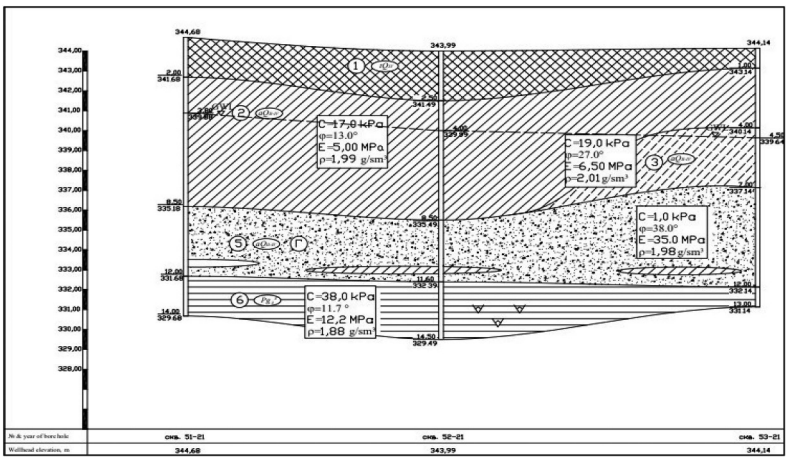

Figure 2. Soil profile at site of Astana medical facility.

3 NUMERICAL MODELING OF DRIVING PILE IN THE PLAXIS 3D

We will calculate the drilling pile using the solutions of the theory of the limit state of a granular medium (numerical methods). When using the numerical method - the finite element method and using the Plaxis application program.

According to the report of Engineering and geological surveys at the facility "800-bed Astana Medical University Hospital" was collected the calculation scheme of the engineering-geological well column No.53–21. Physical and mechanical properties of soils are presented in introduction. The Calculation model of driven test pile 10C-30 was showing in the picture.

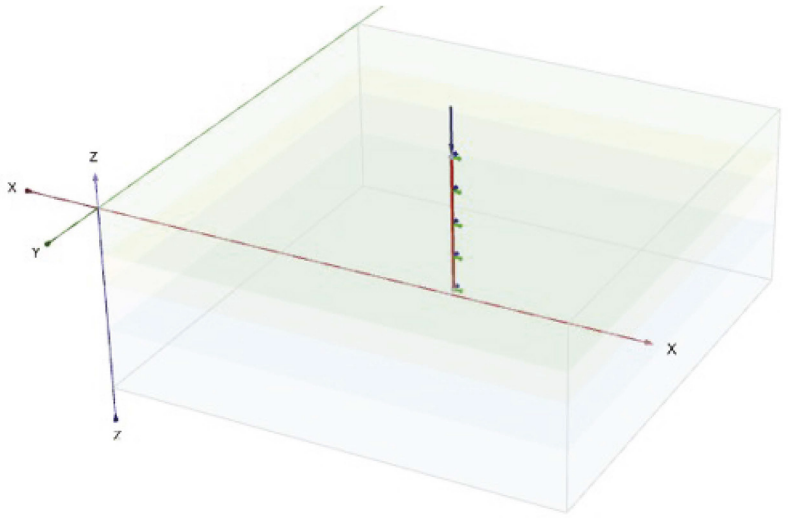

Figure 3. Calculation model of driven pile for Astana site.

To calculate pile, the Linear Elastic model and the Elastic-Plastic model with the Mohr-Coulomb strength criterion were used.

The analysis of the calculation results was performed according to:

- displacement of the pile are showing in the Figures 4–5;

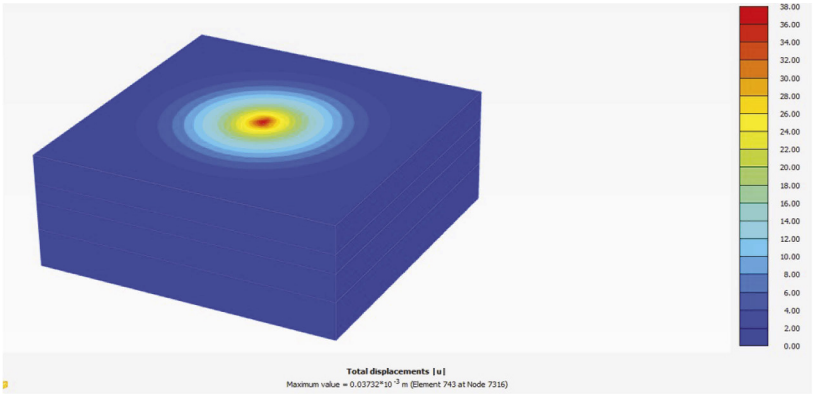

Figure 4. Total displacement of the pile.

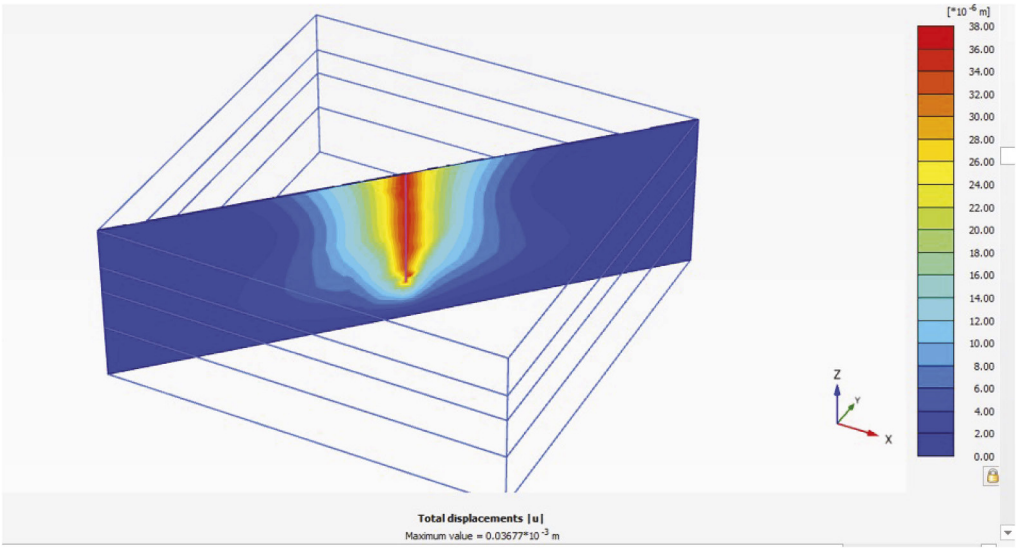

Figure 5. Total displacement of the pile.

The result of the numerical simulation of pile settlement with a design load of 940 kN in the Plaxis 3D software package is:

the settling of the driving pile C10-30 was 38 mm, which is within the normal range according to SP RK 5.01-103-2013. Pile foundations, 2015

4 STATIC PILE TESTS

Field tests of S10-30 driven piles with static, vertical-indentation loads were carried out from December 02, 2020 to January 08, 2021 at the construction site of the Main Building and the Parking lot of the Astana Medical University Hospital in Astana.

The tests were carried out on four driven test piles C10-30 numbered 29, 40 (Main building) and 62, 66 (Parking lot), as shown in Figure 6. The piles were driven to a depth of 9.5 m. Field

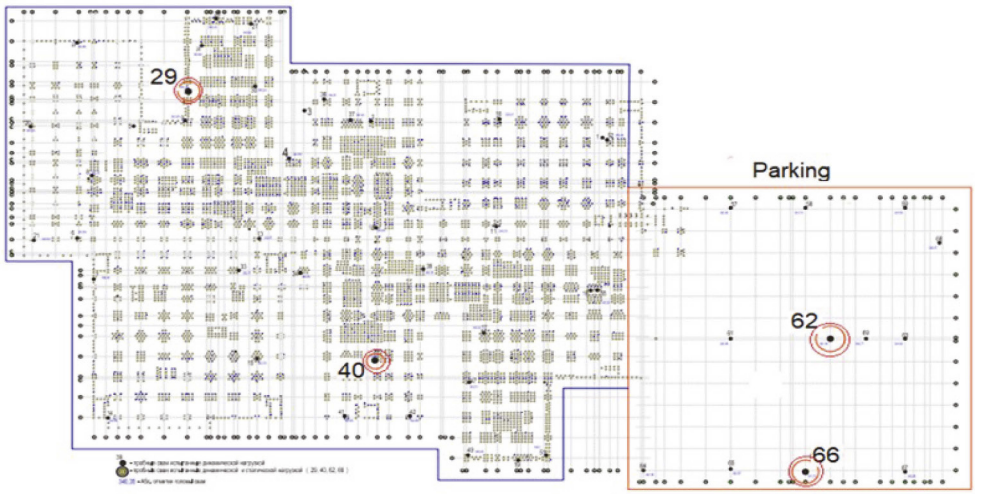

Figure 6. Plan view of static pile test layout at Astana site.

tests were carried out after a period of pile "rest" equal of 30 to 60 days after driving. The load on the pile was created using a 100-ton hydraulic jack "Enerpred DU100P150" with a pumping station "Enerpac P462", abutting against a test and loading stand, weighing 120.0 tons (Tulebekova, et al. 2012), (Zhussupbekov, et al. 2015).

The process is described in detail in the articles previously published. (Turashev, 2015, Yenkebayev, 2012, Tulebekova, 2021). Pile settlement curves are shown in Figure 7.

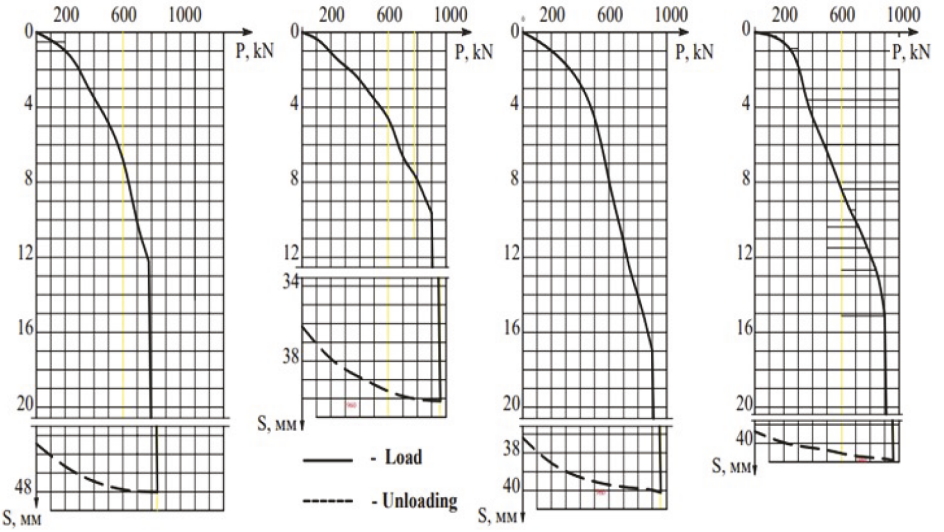

Figure 7. Pile settlement curves for Astana site.

The results of the static pile tests are summarized in Table 2. Some important points regarding the static pile tests at the Astana site are as follows: The bearing capacity of the pile tests at the locations of the main hospital building and the parking structure were 990 kN and 780 kN, respectively. The permissible pile load, taking into account the safety factor $\gamma_k = 1.2$ in accordance with clause 4.4.1.11. SP RK 5.01-103-2013 ("Pile foundations"), is equal to 750 kN and 650 kN for the main hospital building and parking structure locations, respectively.

Table 2. Summary of static test results for Astana site.

Pile №	Depth of immersion of piles in the ground, m	Maximum applied load, kN	Displacement at the highest applied load, mm	Partial value of ultimate resistance, kN	Bearing capacity of piles, kN
№ 62	9.5	840	48.01	780	780
№ 66	9.5	960	40.14	900	
№ 29	9.5	960	40.12	900	900
№ 40	9.5	960	40.91	900	

5 CONCLUSIONS

1. The result of the numerical simulation of pile settlement with a design load of 940 kN in the PLAXIS 3D software package is: the settling of the driving pile C10-30 was 38 mm
2. Static indentation test results must be considered when determining the correct pile length.
3. The results of settlement of the pile, determined by numerical modeling, is slightly lower than from static tests, with a difference in results being in 7%.

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