Comparison of experimental data of model piles in normal and seasonally freezing soil

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ABSTRACT: In this paper describes the applications of model piles in seasonally freezing soil. Were carried out static tests of model piles in the laboratory of Karaganda University (Temirtau, Kazakhstan). The results of the tests determined the behavior of model piles and their load-bearing capacity. Static tests were carried out in accordance with GOST 5686-94. Soil.Pile test loading methods. In conclusion authors give recommendation to pile driving in seasonally freezing soil in consruction site in Kazakhstan.

Keywords: pile foundation, static test, bearing capacity, seasonally freezing soil

1 INTRODUCTION

Construction of pile foundations is very much occurring situation in Kazakhstan (Zhussupbekov et al 2013). Especially many interesting buildings are built by using piles in foundation construction of Kazakhstan. Kazakhstan is located on seasonally climatic area where hot and freeze temperature present during of year. Temperature of freezing could reach sometimes -45 ^{o}C and +45 ^{o}C in summer (Zhussupbekov et al 2012). So the harsh climatic condition like this create a lot of problems related to freezing and thawing of the soil ground (Shakhmov & Zhussupbekov 2015, Zhussupbekov et al 2017). This paper present research about influence of freezing to pile foundations. Model testing of pile in normal and freezing condition is presented in this paper.

2 METHODOLOGY OF THE EXPERIMENT

2.1 *Instruments usage in experiment*

In the construction it is very important to take into account the frost-hazardous properties of soils that can affect the foundations from the negative side (Beskow 1935). Many works are written about the effect of the soil's unprotected properties on foundations on natural grounds. Frost heaving, the strength of the whipping is especially problematic during construction (Zhussupbekov & Shakhmov 2015; Zhussupbekov et al 2017).
The experiment contain from special devices which is helping to get results. Equipment and devices such as next:
- device for pile loading (weight, load);
- supporting structure for the perception of reactive forces (beam system);
- device for measuring the movement of the pile during the test (manometer);
-thermometer;
-Model pile;
- Mechanism of piling and extraction of model piles
- fishing line.
The device for loading piles should provide coaxial and central transfer of loads to the pile, the possibility of transferring the load in steps, the constant pressure at each loading stage.

2.2 *Process of providing experiment*

The experiments were carried out in a tray, which is a frame construction. The capacity for backfilling of the equivalent mixture has dimensions of 0.9 * 0.5 * 0.9m. The frame is intended for attachment of attachments, which in these experiments belonged to a loading device and a system of dial indicators, which allows recording movements.
In the experiments, the work of a single pile was investigated, as well as the work of fragments of pile foundations with piles 18 m long.
Preparation for the experiment was conducted in the following order.
The mixture equivalent to the ground was laid with layers 10 cm thick. The stacked portions of soil were preliminarily weighed, which provided the required specific gravity corresponding to the total deformation modulus E = 1.628-2.035 MPa.
After laying the equivalent mixture, the piles were dipped. To give piles in the ground a strictly vertical position, the immersion was carried out using a conductor, which was set on the level.
After each experiment, the models were dug out, and the results of only those experiments in which the piles did not deviate from the vertical were taken into account. The final piling of the piles to the required depth was carried out after the removal of the conductor.
Load on the foundation model was applied with levers with a ratio of the arms 1:10. The load stages were taken equal to 1/10 ÷ 1/15 of the value of the maximum loads determined by preliminary methodological experiments. Each stage was maintained until complete stabilization of the deformation, after which indicators were taken to determine the movement of the piles.

2.3 *Content and types of the testing*

The experiment consist by two part. First part with normal condition and second part with frozen condition. The features of 1st part presented below:
1. to study the stability of piles of various designs in non-heaped soils with repeated freezing-thawing process
2. to investigate the interaction of the ground base (Determination of the bearing capacity of piles under normal conditions)
3. Calculation for the II group of the limiting state on the compressive thickness
4. Develop a pile model on a scale
5. Install a crate for installing thermometers - 2 pcs.
Calculate the depth of soil freezing on a scale.
Results of experiments with models of piles
1. Analysis of the results of experiments on the stability of piles in non-heaped soils
2. Draw up "sludge-load" graphs based on the results of static pile tests

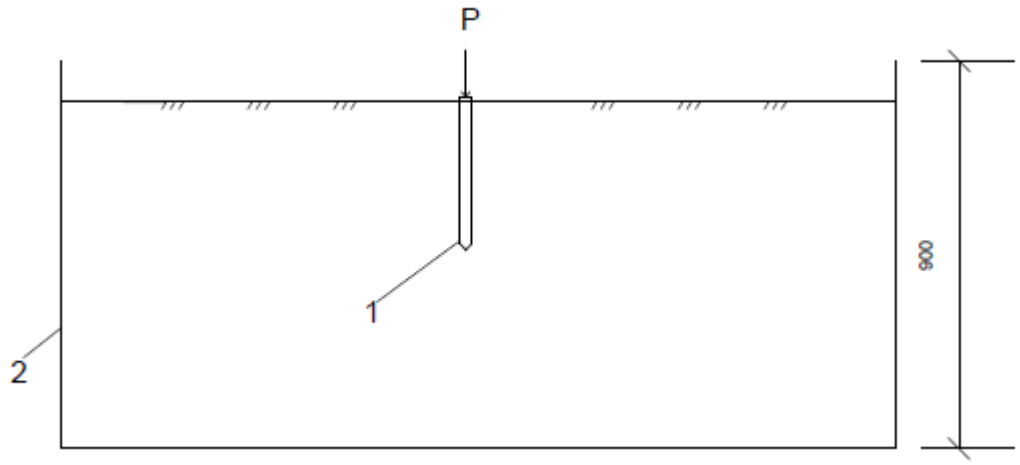

Figure 1. Design scheme of piles under normal conditions (1-pile, 2-tray, 3- equivalent material).

The features of 2st part presented below:
1. for the study of the stability of piles of various designs in ragged soils with repeated freezing-thawing
2. to investigate the interaction of the subsoil base (Determination of the bearing capacity of piles in conditions same to seasonally freezing soils)

3. Calculation for the II group of the limiting state on the compressive thickness
4. Develop a pile model on a scale
5. Install the crate for installing thermometers
6. Calculate the depth of soil freezing on a scale.

Results of experiments with models of piles:

1. Analysis of the results of experiments on the stability of piles in the subsoil soils
2. Compile the "sludge-load" graphs from the static pile tests.

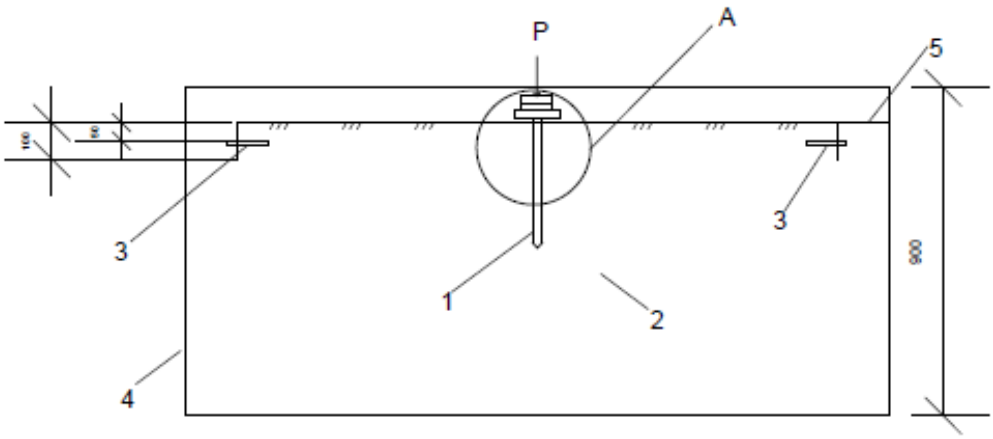

Figure 2. Design scheme of piles under winter conditions (1-model pile, 2- equivalent material, 3- thermometer, 4- tray, 5- technological pits).

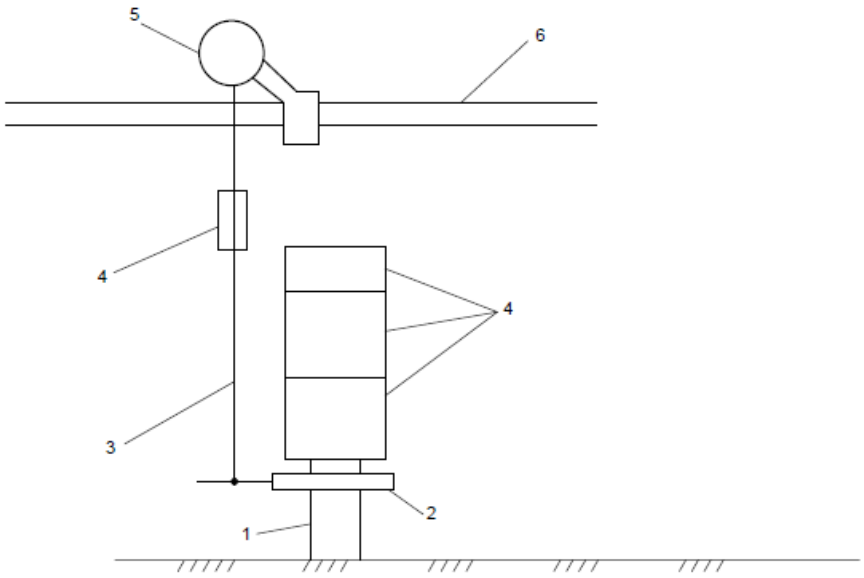

Figure 3. Unit A of Design scheme of piles under winter conditions (1-model pile, 2- clamp, 3- line, 4- congestion, 5- deflectometer clock type, 6-frame by reference system)

Figure 4. Finished testing model at the time of the test.

3 RESULTS AND DUSCUSSION

Model tests of piles in ordinary and frozen ground conditions showed different results. In particular, piles with a length of 3 meters in frozen ground conditions showed an increase in the bearing capacity of almost 3 times greater than in the same length under normal conditions. This is due to the compression of the piles along the perimeter and the freezing of the soils along the sides in connection with the expansion and the pore pressure that occurs during freezing. These tests are presented in comparative form in Table 1.

Table 1. Comparison of pile loads in normal and winter conditions.

Pile L (m)		Normal soil	Frozen soil
Length	Penetration	F_o, kg	$F_м$, kg
3	2,5	4	11
5	4,5	7	13.75
6	5,4	8.75	15.25
10	9,4	14	19.5
12	11,5	17.5	22
14	13,5	20.25	25.25

* Note to table.

The results of the test for clarity are also presented below in the form of two curvilinear graphs in Figure 4, which show more clearly the difference in bearing capacity of piles in ordinary soils and in frozen ground conditions. I would like to note that the effect of freezing on the bearing capacity decreases in direct proportion to the increase in the length of the piles.

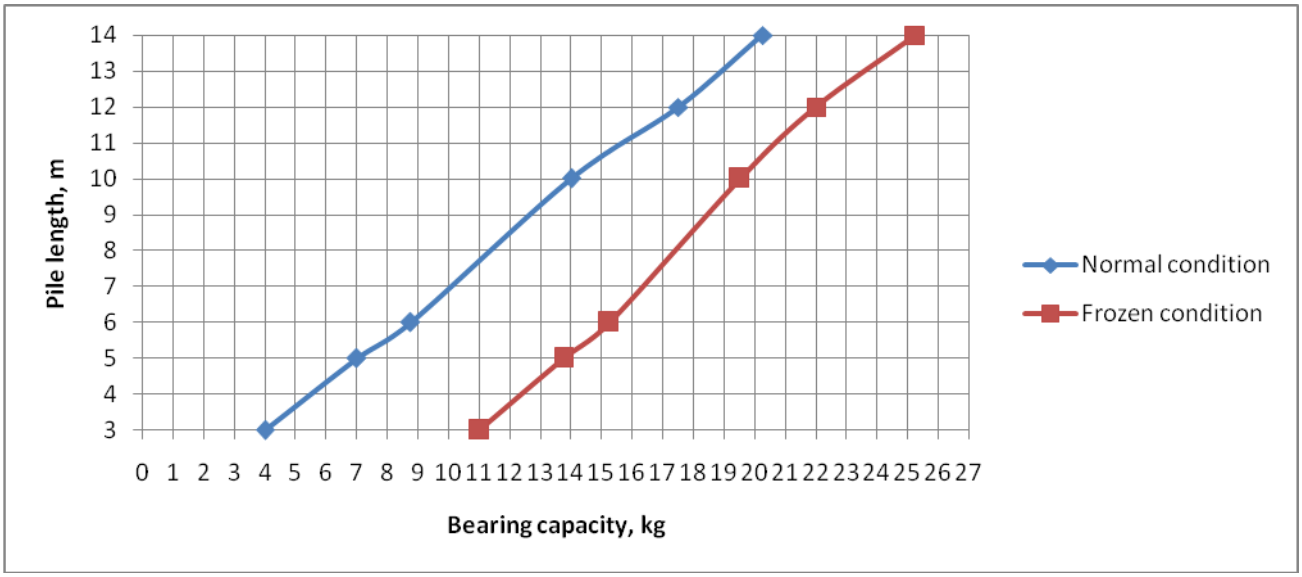

Figure 4.Comparison of bearing capacity in normal and frozen condition soil.

4 CONCLUSION

The tests given above show how freezing can influence the pile foundations, which is very important to consider when testing and determining the bearing capacity of piles. In particular, short piles can show the bearing capacity in the frozen ground state increased by several times, which is very important to take into account when designing pile foundations in winter conditions. As the length increases, this tendency is reduced. We believe that in the future it is necessary to study in more detail the problems of shearing stress during the freezing of soil bases.

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