Offered methods for the determination of bearing capacity of pile regarding types of foundation of Astana city

Propositions pour la détermination de la capacité d'appui de la pile concernant les types de fondation de la ville d'Astana

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ABSTRACT: The paper presented methods of determine of bearing capacity of pile: analytical method and experimental method. Discussion of using technological features, advantages and disadvantages of methods. The paper include method of determine bearing capacity of pile in problematical soil ground of Astana city. The analysis are presented that new method of determine of bearing capacity of pile gives detailed information about the process testing and makes more reliable results. And so researcher of advanced pile technologies is very important for the feature Kazakhstan geotechnic development.

RÉSUMÉ : Le document a présenté des méthodes de détermination de la capacité de tas de la pile: méthode analytique et méthode expérimentale.Discussion sur l'utilisation des caractéristiques technologiques, des avantages et des inconvénients des méthodes. Le document comprend une méthode de détermination de la capacité de palier de la pile dans les sols problématiques de la ville d'Astana. L'analyse est présentée dans le document montre que la nouvelle méthode de détermination de la capacité de tas de pile fournit des informations détaillées sur les tests de processus et donne des résultats plus fiables. Et donc le chercheur des technologies de pilotes avancées est très important pour la fonctionnalité du développement géotechnique du Kazakhstan.

KEYWORDS: pile, test, bearing capacity, method.

1 INTRODUCTION

Experience driving the piles, saved up lately, and results of their tests testify that designers overestimate length of piles on the average for 1-2 m that causes additional rise in price connected with necessity cutdowm sticking out goals by means of specially created mechanisms, and sometimes even manually. Tests of such piles «not finished» up to design marks show their quite sufficient bearing capacity (Narbut 1972).

As bearing capacity of a pile define not only a limiting condition of a material of a pile or a ground near it, but also the size of the loading corresponding admissible settlement for certain type of a construction. At that bearing capacity of a pile on soils depends on mechanical properties of soils and from a method of the device or immersing of a pile. And on a fuctioning of a pile under action of static loading the big influence is rendered with the changes occuring in the surrounding ground at driving of piles (Pilyagin A.V. and Glushkov V.E. 1989).

Besides, the numerous researches lead by various authors, have shown, that at driving piles irrespective of depth immersing in the multilayered basis the condensed sandwich shell is formed

As at immersing a pile in sand around of it there are ring condensation in radius of 2-6 diameters of a pile depending on personal density of soils. Under an edge of a pile the condensed zone extends on depth equal 2 diameters of a pile.

And at driving piles in clay soils the pile at immersing moves apart soil, and the edge forms the condensed zone in the form of a wedge which depends on property of soil and from depth of immersing of a pile. The condensed zone under influence of resistance of underlaying layers gradually is pushed out from under an edge of a pile and placed around its lateral surface, forming a concentric environment which thickness will decrease until all stock of the grasped ground will not be spent.

Besides at driving piles in clay soils there is a sharp decrease in durability of a ground in connection with redistribution of water in times of soil and destruction of structural communications. Then during rest it is observed thixotropycal hardening of these soils, that conducts to increase in bearing ability of piles. Hardening is connected with process of redistribution of a moisture. Water environments around of the particles which are settling down about piles, gradually resolves, causing increase of durability coagulation communications and by that soil. In time this process proceeds differently, depending on features of soils, but gradually it fades. The increase in bearing capacity of the piles shipped in sandy loams, practically comes to an end later 5 days, in loams basically in 15 days, in clay 25-30 days.

During «rest» within the limits of the specified terms bearing capacity of piles raises quickly enough, and then increase hardening of soil occurs already so slowly, that it seldom has practical value.

The account of «rest» allows to define more precisely bearing capacity of piles and enables to appoint higher calculation resistance.

For a correct estimation kinetics increases in bearing capacity of the piles, shipped in soil, huge value the has method of its definition, in some cases even influencing on size of bearing capacity (SNIP RK 2002).

2 METHODS FOR DETERMINE THE BEARING CAPACITY OF PILE

Existing methods of definition of bearing ability of piles are divided in two basic groups:

1) the analytical methods using the theories of limiting balance, the theory of elasticity and model linear deformations of soils.

2) the experimental methods based on field tests, to which concern penetration (static and dynamic), static and dynamic tests of piles, tests of soils reference piles, pressing tests.

2.1 *Analytical methods of definition of bearing capacity of piles*

At an estimation of bearing ability of piles calculation on two groups of limiting state: on bearing capacity (I group) when the maximum load on a pile is calculated, and on deformations (II group) when loading on a pile depending is defined on its settlement (Citovich N.A. 1979, Dalmatov B.I. 2000).

In many methods bearing capacity is characterized as the sum of resistance under the bottom end and on its lateral surface (see Figure 1). For the first time such approach at an estimation of a maximum load on a pile has been made by Patton in 1895, and till now this way applied in native and foreign normative documents.

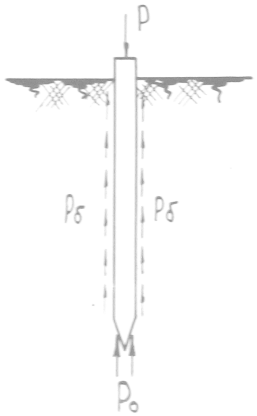


Figure 1. Scheme of work of a trailing pile under loading.

At a stage of design engineering the method of definition of bearing capacity of piles in conformity with SNIP RK 5.01-03-2002 under the following formula is widely used:

$$F_d = \gamma_c \cdot \left(\gamma_{cR} \cdot R^H \cdot A + u \sum \gamma_{cf} \cdot f_i \cdot h_i\right), \qquad (1)$$

where γ_c - factor of operating conditions of a pile in soil, accepted equal 1;

R^n - calculation resistance of soil under the bottom end of a pile, kPa, accepted with normative table 1 (SNIP RK 2002).;

A - the area lean on a soil of a pile, м^2, accepted on the area of cross-section section of a pile gross or on the area of cross section unpleasant enlargement on its greatest diameter, or on the area of a pile-environment net;

U - external perimeter of cross section of a trunk of a pile, m;

f_i - calculation resistance i layer of a soil on a lateral surface of a pile, kPa, accepted under normative table 2 (SNIP RK 2002).;

h_i - thickness i layer of the soil adjoining a lateral surface of a pile, m;

γ_{cR} and γ_{cf} - factors of operating conditions of a soil accordingly under the bottom end and on a lateral surface the piles considering influence of a way of immersing of a pile on calculation resistance of a soil and accepted with normative table 3 (SNIP RK 2002).

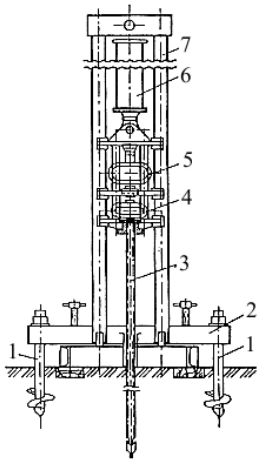
The structure of the formula (1) precisely enough reflects a fuctioning of piles in a soil and is calculated as the sum of resistance of soils under its bottom end and on a lateral surface. However, definition by this way of limiting resistance approximately as it is difficult to divide lateral and frontal resistance which are shown in full interrelation. Average skilled data normative specific frontal R^n and lateral f_i not always answer real conditions and depend on geological conditions of a platform which can strongly change during construction.

As tables of settlement resistance in SNiP RK 5.01-03-2002 are received on the basis of processing results of tests more than 200 piles of the various kinds lead by Luga A.A., and as calculation the guaranteed least values of the given tests have been accepted. Therefore in this case results of calculations of bearing capacity of trailing piles by technique SNiP give a greater deviation from really received results, especially on weak soils.

Besides at purpose of normative sizes R^n and f_i are not considered possible change of humidity of soils as a result of construction of a building as the specified parameters only depend on a parameter of fluidity (consistence) I_L. As these characteristics (humidity of a ground, a consistence) rather essentially change even within the limits of one investigated thickness. Especially more mistakes arise at reception of settlement characteristics at small volume of researches, and the error can result as in overestimate of settlement characteristics, and understating. Therefore, the bearing capacity, determined by the calculation, requires comparison with the results of practical material obtained by field tests of piles.

2.2 *Field tests of piles for bearing capacity*

At designing the piles foundationss by one of the most widespread and effective methods of definition of bearing capacity is static penetration (Figure 2) (Mariupolskiyi L.G. 1984, Trofimenkov U.G. and Vorobkov L.N. 1974).



1 - screw anchoring piles; 2 - a frame; 3 - a probe;
4 and 5 - dynamometers; 6 - a jack; 7 - directing

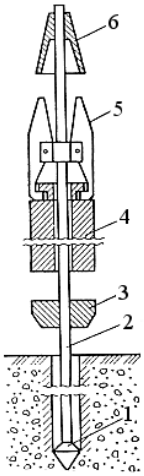
Figure 2. Scheme of immersing of a probe at static penetration.

For the first time the method of definition of bearing capacity of piles according to static sounding has been regulated by native norms in 1987 (SNiP II-Б.5-67). In the further, on the basis of the lead researches, the method has been specified for various types of probes and kinds of soils (GOST 2001).

Carrying out of field test of soils is regulated by static penetration GOST 19912-2001 (GOST 2001).

At that static penetration is applied to test not frozen and thawed sandy-clay soils, 10 mm are larger than 25 % of particles containing no more.

And for research of the sandy-clay strains containing no more of 40 % coarsefragmental of a material, on depth up to 20 m dynamic penetration (Figure 3) is intended.



1 - a conic tip; 2 - a bar of a probe; 3 - an anvil; 4 - hammer;
5 - capture of hammer; 6 - the terminator of height of rise of hammer
Figure 3. Scheme of installation of dynamic penetration.

By means of this method it is possible:

- to dismember a cut of breeds on the layers, differing resistance dynamic penetration with high accuracy (up to 0.05);
- to establish their degree of uniformity, to define parameters of some properties and depth driving piles.

Carrying out of the given field test of soils also is regulated GOST 19912-2001 (GOST 2001).

But as practice of designing of the pile bases bearing capacity of piles certain by results of static and dynamic penetration on 25 % on the average above bearing capacity certain by calculation and more reliable results of bearing capacity of pile can be received at carrying out static test (Figure 4). However, the quantity of predesign static tests of trial piles is very limited 2-4 piles for a quarter in connection with high expenses at carrying out of the given tests.

Figure 4. Test by static loadings.

In this connection apply more mobile and not demanding high expenses a dynamic test method of piles which is applied to any kinds of piles, irrespective of their bearing capacity is more often, does not damage working capacity of piles and guarantees reception of the most exact information on bearing capacity of a pile (Figure 5). Besides the given test allows to estimate approximately uniformity soils the bases, revealing sites, described in various density and as to specify length of a pile (GOST 1994).

Figure 5. Test by dynamic loading.

3 METHOD OF DETERMINE BEARING CAPASITY OF PILE IN PROBLEMATICAL SOIL OF ASTANA

Based on the results of static tests of piles carried out on construction sites in Astana, the bearing capacity of piles, brought to an unloading draft of 6 mm (BS 1996 and BS EN 1997), corresponds to results bearing capacity of pile at dynamic tests of piles, apparently from the schedule. Therefore calculation bearing capacity of piles has been compared to results of dynamic tests of pile taking into account types of the bases (Figure 6) (Zhusupbekov 2011)..

As a result of the analysis it has been established, that bearing ability of piles at static tests F_d in 98 cases (79 %) was more loading F_d^c transferred to a pile at construction. The deviation F_d from F_d^c no more than on 10 % (both sides) has been noted 24 piles (19 %) and only in 33 cases (26 %) the deviation has made no more than 20 %. At 67 piles (54 %) value of bearing capacity at dynamic tests the loadings transferred pile at construction (Figure 6). Hence, the given bases have greater and unjustified stocks.

In addition, reliability coefficients were established for all tested piles, taking into account the type of the base (see Figure 7), on the basis of comparing the values of the dynamic tests with the estimated values of the bearing capacity in accordance with SNiP RK 5.01-03-2002 (see Table 1 and Figure 8), which take into account the working conditions of the pile in the ground.

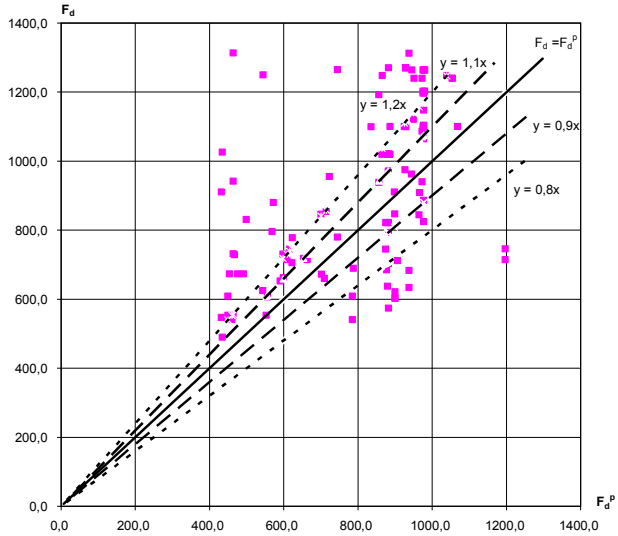
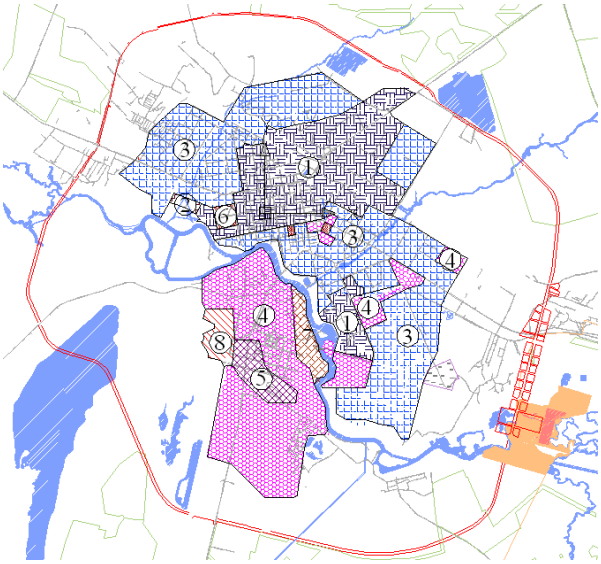


Figure 6. Comparison of values of loading at construction with sizes of bearing capacity on static tests of piles.



1 type	2 type	3 type	4 type	5 type	6 type	7type	8 type
EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1
EGE-2a	EGE-2d	EGE-2a	EGE-2	EGE-2a	EGE-2a	EGE-2a	EGE-2d
EGE-4	EGE-2a	EGE-3a	EGE-3a	EGE-3b	EGE-2b	EGE-2b	EGE-2a
	EGE-4	EGE-4	EGE-3b	EGE-3c	EGE-4	EGE-3a	EGE-3a
			EGE-3c	EGE-5		EGE-3b	EGE-3b
			EGE-4			EGE-3c	EGE-3c
						EGE-4	EGE-4

Figure 7. Zoning of the territory of Astana city according to foundation types.

Table 1. Value of factor of reliability calculations of bearing capacity $K_d = F_d^c / F_d$

	Types of basis							
	1	2	3	4	5	6	7	8
Value of factor of reliability $K_d = F_d^c / F_d$	1,22	1,23	0,81	0,85	0,91	1,00	1,02	1,03
Number of tested piles	103	14	64	184	91	34	26	13

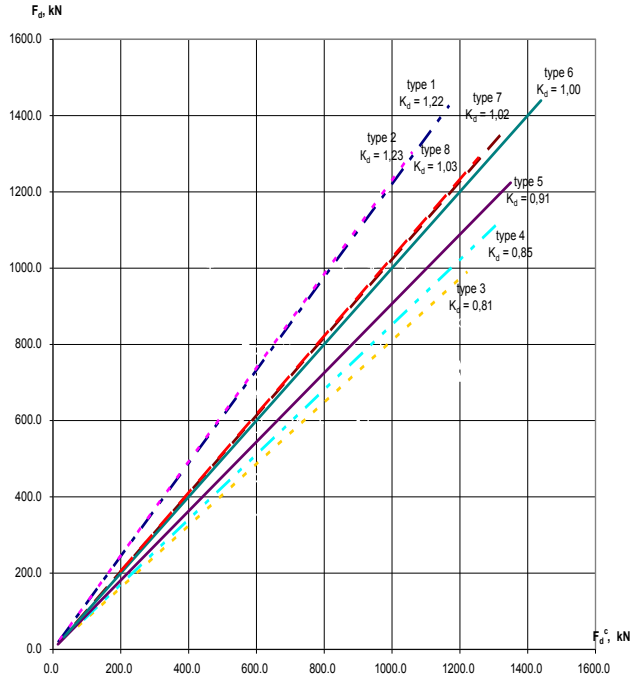


Figure 8 Comparison of values of dynamic tests with calculation sizes on SNiP RK 5.01-03-2002 taking into account types of basis

4 CONCLUSION

The analysis in the article shows that the method of determine of bearing capacity of pile makes more reliable and gives detailed information about the process of testing and the results. Actual question today is to update the national standards, harmonization with international standards. The method which described is very important for the feature Kazakhstan geotechnical development.

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