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Research Article

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THE TECHNOLOGY DEVELOPMENT OF THE WIDENED BASE FORMATION FOR BORED PILES

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ABSTRACT

Bored piles are used at the high concentrated vertical and horizontal loads in the construction sites with complicated geological and engineering conditions. They are support elements, which transfer and distribute the load from buildings to hard layers of soil. Technology of the bored piles making is drilling of bore in soil and placement of concrete mix into the bore.

The main advantages of bored piles are that no need to store a large number of prefabricated piles at the construction sites, high load-bearing capacity and efficiency at the implementation. Moreover, the most important advantage of bored piles, as compared with the prefabricated piles, is absence of dynamic and noise load on nearby buildings during execution of construction works. However, we have to stress a disadvantage of the technology of the bored piles making, which is the need of the bore drilling and the widened base formation to increase of the load capacity of bored pile. The aim of the research work is to improve the technology of the bored piles making by developing the equipment for the widened base formation. We propose a new equipment to form the widened base, protected by a Patent of the Republic of Belarus No.1823. The detailed description of design and principle of operation of the new equipment, as well as comparison with existing analogues are given in the research work. The use of the new equipment allows reducing labor expenditures and cost of the widened base formation for bored piles.

Keywords: Bored piles, Widened base, Barrel, Blade, Soil

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INTRODUCTION

Nowadays, pile foundations are often used in construction in the conditions of existing buildings, in cramped conditions, on steep slopes, for large construction, in areas where weak, marshy and saturated soils with low strength, and in the Far North with permafrost soils. Many researchers revealed that pile foundation has a number of advantages as compared with other types of foundations.

An increasing use is being bored piles among a wide variety of piles. Bored piles are recommended to apply preferably with a length of more than 10 m, but piles of shorter length - for light or medium loads (for example, for farm buildings) where there is no industrial base for manufacturing of precast concrete piles.

The piles are widened at the bottom to increase their load capacity (fig. 1). The necessity of complicated and expensive equipment arises to perform the widened base for the bored piles. However, even the use of such complicated and expensive equipment does not allow solving a technical problem of reinforcing the widened base.

The most relevant and challenging tasks in the field of pile foundation is the development, study and introduction of high-performance economical and reliable structures of piles that submerge with minimal energy consumption and ensures a high load-bearing capacity of the soil base (Ai and Liu, 2015, Gabrielaitis et al., 2013; Sakr M., 2013).

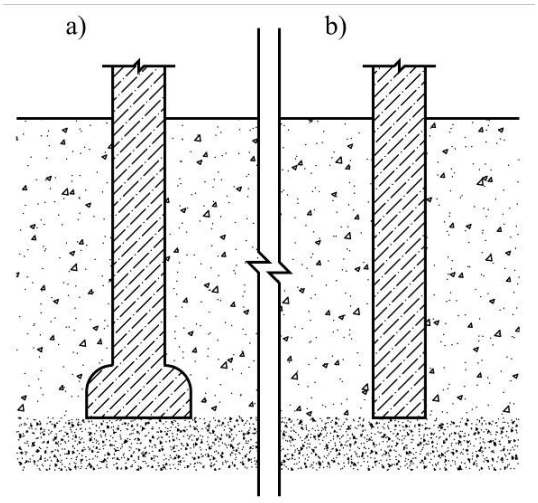

Fig.1. Scheme of bored piles

a) with widened base; b) without widened base

A significant number of leading experts in this field studies application technologies and issues, arising with this problem in pile foundations. Results of theoretical and practical studies are presented in Russian and international scientific publications.

Teixeira et al. (2012) noted that pile foundation can be erected at any type of soil (except the rock), and emphasized that little horizontal reinforcement in the bottom of single pile could reduce the resistance under axial load.

Liu et al. (2014) wrote about the effectiveness of pile foundation in the viscoelastic saturated soils. They performed an analytical calculation of vertical reaction of pile that occurs at the influence of pullout forces.

Heidari et al. (2014), Li et al. (2008) and Xu et al. (2014) revealed that pile foundation withstands considerable loads. They simulated the wave propagation in saturated soil and obtained the pullout effect of piles.

Zheng et al. (2015) and Kamal et al. (2016) asserted that widened base increases the load-bearing capacity of pile at the dynamic loads.

Li and Xu (2008) noted that pile foundation can be constructed at any time of the year, and studied the work of piles on pullout and in permafrost soils.

Abdrabbo and Ali (2015) revealed that distribution of axial load and shear stress depends on the density of pile field.

Abdrabbo and Abouseeda (2002) asserted that construction of bored pile foundation is at least 40% cheaper than the strip foundation, and noted that there are the number of problems that arise during the application of existing equipment for the formation of bored piles and the necessity of experienced and qualified workers.

At a slightest deviation from the technological process can be a tilt or even the collapse of adjacent existing buildings. Analysis of the studies of leading scientists has shown that the existing technology of widening the base for bored piles requires an expensive equipment and highly trained workers to use it.

There are the number of devices for widening the base and technologies of their application (Alkroosh et al., 2015; Chernuk and Stashevskaya, 2003; Stashevskaya et al., 2010; Verstov and Gaydo, 2010).

Despite the use of expensive equipment, the solutions on the implementation of horizontal reinforcement of the widened base, despite the relevance of problem, there are no proposal by the researchers.

In this case, the aim of the research work is to improve the technology of the bored piles making by developing the equipment for the widened base formation.

MATERIALS AND METHODS OF RESEARCH

We made research and found the technical solution with proposing a new equipment (fig. 2-4) that enables:

- to simplify the technology of widening the base;
- to achieve the implementation of horizontal reinforcement of the widened base for the bored pile.

The equipment consists of barrel (1) with the pointed plates (2) attached to the barrel (fig. 2). Pointed plates (2) were made in the form of curved elastically malleable plates. Upper part of the blades are rigidly attached by welding to the lower part of the surface of barrel (1) at an angle of 5–10° to the longitudinal axis of the barrel (1). Pointed plates (2) are sharpened at the bottom and made longer than the lower end of the barrel (1).

The pointed plates (2) are supported in the bottom of borehole and, due to the presence of bevels at the lower ends, the lower part of the pointed plates are folding and cut into the soil (fig. 3), forming the widened base.

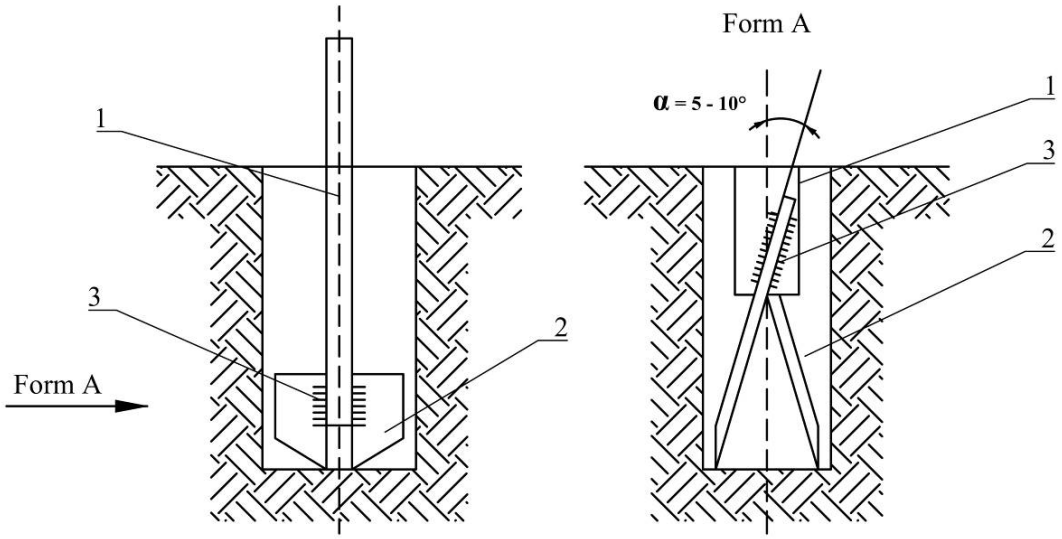

Fig.2. Dipping the equipment into the Soil

1 - barrel; 2 - pointed plates (thickness = 3-4 mm); 3 - welded joints

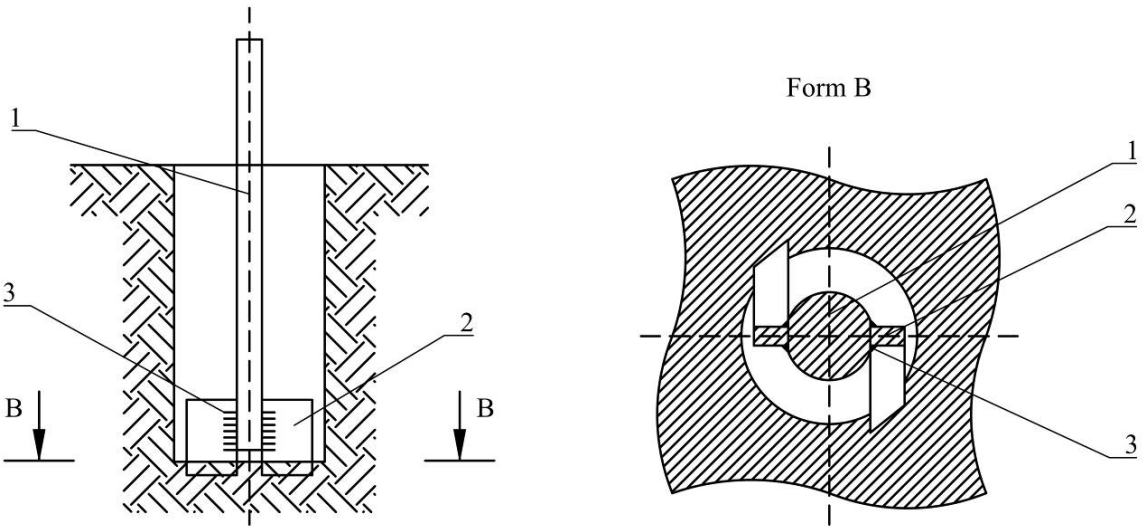

Fig.3. Dipping the equipment into the Soil

1 - barrel; 2 - pointed plates; 3 - welded joints

Concreting of borehole is carried out after the full disclosure of pointed plates (fig. 4). Concreting of borehole is recommended according to the technology, described below.

Concrete-pouring tube with drain funnel is moved down into the borehole. Concrete-pouring pipe can be used sectional, telescopic or with joints of various structures. Concrete is supplied to the receiving funnel of concrete-pouring pipe directly from the concrete mixer or from a receiving bunker in which unloads the concrete mix.

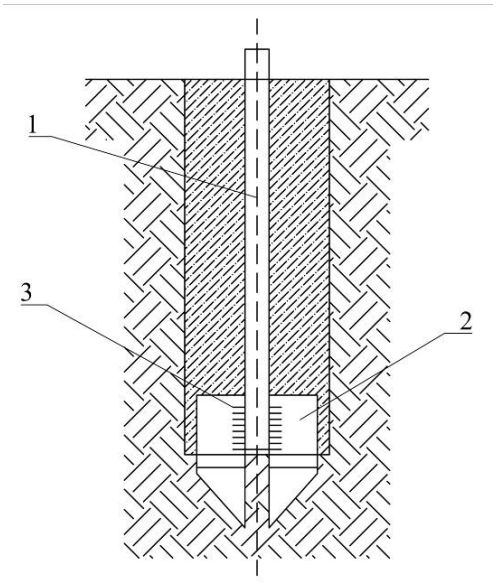

Fig.4. Bored pile after the borehole concreting

1 - barrel; 2 - pointed plates; 3 - welded joints

It is recommended to use the concrete with the compressive strength of 300 kg/m^2 with cement content of at least 340 kg/m^3 and the slump of 21 cm. Fine aggregate should contain at least 25% with a maximum size of 0.1 mm; coarse aggregates is 5-20 mm with the strength of 50-60 MPa. Pile concreting is performed by moving the concrete-pouring tube vertically. During concreting, the concrete-pouring tube should be gradually removed from the borehole, reducing its length by decreasing the number of sections. In order to speed up the operation of decoupling, quick-decoupling hose clamps are used.

Concreting experience shows that the concrete-pouring tube is better to fix with the bottom valve. This valve has a rubber seal that pressed to the end of the tube by a latch with a spring just before the opening of the valve.

Concrete-pouring tube with the closed bottom valve is moved down completely into the borehole in its bottom, whereupon the tube and its receiving hopper is filled with concrete mix. Then, the tube is moving upward. Under the pressure of concreting the valve opens, after that the concrete fills the borehole, which is to be concreted.

During the pile concreting the pressure in concrete mix should be constant. If the pressure drops, the lifting speed of concrete-pouring tube should be reduced. Concrete compaction is performed by using the vibrators, which are fixed to the concrete-pouring tube. Concreting should be performed until the concrete mix come out to the surface and ends with the removal of the taint layer of concrete. After that, the inventory jig is set and the pile head is concreted.

RESULTS AND DISCUSSION

The advantages of a new technology are identified only after its comparative assessment with the previous technology for the efficiency criterions, which are cost of products, labor input and operation time.

Our research results show that proposed equipment can be competitive and it has the number of advantages as compared with the equipment, which is used in the production of pile foundations, connected with the reduction of cost, labor input and operation time of drilling and the widened base formation of bored piles (table 1).

Table 1. Comparison of different equipment for the formation of widened base bored piles

Parameters	Equipment for the formation of widened base bored piles					
	BG 28	USG-012	CO-2	BM-3002	BKM-1501	Proposed equipment
Diameter of drill hole [mm]	1500-2000	600-1000	250-600	600-800	350-600	500-700
Max. Diameter of the widened base [mm]	-	1200	800	1000	800	1000
Maximum depth of drilling [m]	70	40	30	30	30	30
Angle of drilling	5-15	5-15	5-10	5-10	5-10	5-10
Maximum rotating moment of drill [kN·m]	275	140	21.4	114	14.7	150
Axial load of drill [kN]	200	120	22	200	100	120
Rotational speed of drilling equipment [min^{-1}]	35	30	43	49	50	32
Speed of drilling and the widened base formation [m/hour]	3.5-7	2-5	2-5	4-7	2-5	4-7
Labor input of drilling and the widened base formation [machine hour/m]	0.14-0.3	0.2-0.5	0.2-0.5	0.14-0.25	0.2-0.5	0.14-0.25
Cost of drilling and the widened base formation [USD/m]	14.5	11.3	10.8	13.8	10.1	9.4

According to table 1, the proposed equipment can be used effectively for the depth of drilling not more than 30 m, but in this range, it has minimum cost of drilling and the widened base formation as compared with considered types of equipment.

CONCLUSION

The described bored pile equipment is simple in structure. Its use in technology of formation of widened base for the bored piles does not require expensive equipment and highly trained personnel.

It allows reducing material costs for piling at least 14% in comparison with the current technologies of bored piles for the widened base, taking into account the cost of widener and barrel with pointed plates, which remains in the body of the pile.

The described bored pile equipment has an increased load-bearing capacity of the foundation soil.

Experimentally founded that the pile can lean on the soil layer by the proposed bored pile structure with a rated resistance of at least 0.9 MPa.

The most effective use of these piles is in the areas of weak, marshy and saturated soils, as well as in the Far North with permafrost soils.

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REFERENCES

Abdrabbo F.M., Abouseeda H. (2002) Effect of construction procedures on the performance of bored piles. Proceedings of the Deep Foundations Congress 2002 - International Perspective on Theory, Design, Construction, and Performance. Orlando, FL; United States. Geotechnical Special Publication No. 116: 1438-1454.

Abdrabbo F.M., Ali N.A. (2015). Behavior of single pile in consolidating soil. Alexandria Engineering Journal, Vol. 54(3): 481-495.

Ai Z.Y., Liu C.L. (2015). Vertical vibration of a pile in transversely isotropic multilayered soils. Journal of Sound and Vibration, Vol. 357: 145-155.

Alkroosh L.S., Bahadori M., Nikraz H., Bahadori A. (2015). Regressive approach for predicting bearing capacity of bored piles from cone penetration test data. Journal of Rock Mechanics and Geotechnical Engineering, Vol. 7(5): 584-592.

Chernuk V.P., Stashevskaya N.A. (2003). Device for the formation of a broadened foundation of bored piles. Patent No. 1823, the Republic of Belarus. Available online at: http://bypatents.com/patents/stashevskaya-nadezhda-aleksandrovna

Gabrielaitis L., Papinigis V., Žaržojus G. (2013). Estimation of Settlements of Bored Piles Foundation. Procedia Engineering, Vol. 57: 287-293.

Heidari M., Naggar H.E., Jahanandish M., Ghahramani A. (2014). Generalized cyclic p-y curve modeling for analysis of laterally loaded piles. Soil Dynamics and Earthquake Engineering, Vol. 63: 138-149.

Kamal Z.A., Arab M.G., Adel Dif (2016). Analysis of the arching phenomenon of bored piles in sand. Alexandria Engineering Journal, Vol. 55(3): 2639-2645.

Li D.Q., Tang W.H., Zhang L.M. (2008). Updating occurrence probability and size of defect for bored piles. Structural Safety, Vol. 30(2): 130-143.

Li N., Xu B. (2008). A new type of pile used in frozen soil foundation. Cold Regions Science and Technology, Vol. 53(3): 355-368.

Liu H., Zheng C., Ding X., Qin H. (2014). Vertical dynamic response of a pipe pile in saturated soil layer. Computers and Geotechnics, Vol. 61: 57-66.

Sakr M. (2013). Comparison between high strain dynamic and static load tests of helical piles in cohesive soils. Soil Dynamics and Earthquake Engineering, Vol. 54: 20-30.

Stashevskaya N. A., Nikolenko Y.V., Malov A.N., Krivoshapko S.N., Zadiranov A.N. (2010). Device for the Formation of a Broadened Foundation of Bored Piles. Bulletin of the Peoples' Friendship University of Russia, Engineering Studies, Vol. 2: 11-14. Available online at: https://elibrary.ru/item.asp?id=14999848

Teixeira A., Honjo Y., Correia A.G., Henriques A.A. (2012). Sensitivity analysis of vertically loaded pile reliability. Soils and Foundations, Vol. 52(6): 1118-1129.

Verstov V.V., Gaydo A.N. (2010). The technology of the pile Foundation. Saint-Petersburg State University of Architecture and Civil Engineering, St. Petersburg, Russia. Available online at: https://elibrary.ru/item.asp?id=19631869

Xu H., Chen L., Deng J. (2014). Uplift tests of jet mixing anchor pile. Soils and Foundations, Vol. 54(2): 168-175.

Zheng C., Kouretzis G.P., Sloan S.W., Liu H., Ding X. (2015). Vertical vibration of an elastic pile embedded in poroelastic soil. Soil Dynamics and Earthquake Engineering, Vol. 77: 177-181.

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