New Method For The Construction Of Pile Foundations In Low-Rise Constructions Using Micro-Piles In The Knocked-Out Wells

S N Zolotuchin¹, K K Novikova¹, M S Kim¹

¹Russia, VSTU, department of BCB&F

E-mail: karinanov97@gmail.com

Abstract. The high cost of ribbon foundations, reinforced concrete piles and metal piles, the complexity of such work requires the introduction of a promising method of pile foundations, which are particularly suitable for areas with complex hydrogeological conditions, one of which is the Voronezh Region. A new method for the construction of pile foundations is presented, consisting in the device of micropiles in the knocked-out wells directly on the construction site by using the nozzle on the excavator. The nozzle is a metal pipe with a replaceable steel tip with a diameter of 0.12 to 0.87 m and a length of 0.8 to 3.5 m. Piles are monolithic (made on a construction site). The study of this technology allowed to find out that the use of the nozzle in the device of micropiles reduces the material consumption of works and increases productivity, greatly simplifying the process of construction of pile foundations.

1. Introduction
In view of the fact that the cost of the construction of band foundations, which are the most common at present in construction, is up to 30% of the total estimated cost of building low-rise buildings and buildings using lightweight load-bearing and enclosing structures, installing foundations for fences, now it is necessary to consider the use of pile foundations, which allow to sharply reduce the material, labor and cost.

2. Scientific significance
We decided to conduct an analysis of existing structures and technologies for pile foundation and arrange the data in the form of a table [1-3].

Table 1. Advantages and disadvantages of existing methods

| Name of the method | Advantages | Disadvantages |
|--------------------|------------|---------------|
| Stuffing of reinforced concrete piles | 1) High load-bearing capacity; 2) sophistication of technology | 1) Inability to work in difficult conditions; on steep slopes, with strengthening the hollows of foundations due to the cumbersomeness of equipment and its low maneuverability; 2) A high degree of material consumption during the stumping of the pile head; 3) high cost of piling (6.5 and more thousand rubles), transportation costs |
Table 1. Advantages and disadvantages of existing methods

| Technology of pile pressing | Advantages | Disadvantages |
|-----------------------------|------------|---------------|
| 1) high load bearing capacity; 2) sophistication of technology | 1) Inability to work in difficult conditions: on steep slopes, with strengthening the hollows of foundations due to the cumbersomeness of equipment and its low maneuverability; 2) high cost of piling (more than 6 thousand rubles), transportation costs |
| 1) rational material consumption; 2) production speed | 1) partial decompaction of ground during drilling; 2) high cost of piles (3 thousand rubles) |
| The construction of rammed piles | 1) high load bearing capacity; 2) the possibility of work on slopes and in places with a high level of groundwater | 1) partial decompaction of ground during drilling; 2) labor input; 3) lack of control over soil decomposition under the base of the pile; 4) the tendency to corrosion at a high level of groundwater and an incorrect pile arrangement; 5) high cost of piles (3,5 thousand rubles) |

Fig. 1. Equipment for pile pressing

Fig. 2. Stump of pile heads

Fig. 3. Equipment for driving reinforced concrete piles
Analyzing the above data (see Figures 1-5), it can be seen that the shortage of all existing methods is the high cost of piles, labor, complexity when working in places with a high level of groundwater, as well as performing works such as:
2. the construction of foundations for low-rise building;
3. strengthening landslide slopes in places where it is impossible to use heavy equipment;
4. strengthening of soils under crash foundations;
5. construction of foundations under fences.

3. Goals and objectives
The purpose of this study is: for the development of micro-piles in the construction of foundations for low-rise buildings, when carrying out anti-landslide measures on steep slopes, strengthening crash foundation, compaction of foundation hollows and foundation for fences, the engineering method for designing micro-piles with finding the optimal geometric design parameters, determination of the bearing capacity of micro-piles, a method for calculating foundations on micro-piles, taking into account the mutual influence of all structural element [4-11].
To achieve this goal, the following tasks were accomplished:
1. Numerical modeling by the finite element method was carried out using the program Mides complex of the stress-strain state of the base without strengthening by micro-piles and using single micro-piles and foundations on micro-piles with a high and low grillage (see Figure 6.7).
2. The technology of the construction of the pile foundations with use of micro-piles is developed.
4. Theoretical part. Research results

Studies have been carried out to determine the bearing capacity of micro-piles depending on the geometric dimensions of the nozzle used for the pile assembly and the type of bottom soils (see Table 2). Since the study was carried out in the Voronezh region, the soils that were investigated are clay (sandy loam, loam and clay) [12].

Calculations showed that the greatest load-carrying capacity is provided on a hard clayey soil (loam and sandy loam) and at the largest diameter (0.87 m) - 166.82 kN. In further studies, it is necessary to check the optimal distance between the piles without destroying the adjacent pile when the construction is new, and practice the technology in use on steep slopes.

Table 2. Bearing capacity of micro-piles relative to the geometric dimensions of the nozzle

| Geometrical dimensions of the nozzle, diameter, m, length, m | Type of foundation soil |  |
|-----------------------------------------------------------|-------------------------|---|
|                                                           | Loam solid               | Sandy loam solid | Clay semi-solid |
| 0,12x0,8                                                  | 38,58                    | 38,58 kN         | 30,67 kN        |
| 0,12x1,5                                                  | 38,88                    | 38,88 kN         | 30,97 kN        |
| 0,87x0,92                                                 | 166,82 kN                | 166,82 kN        | 125,24 kN       |

5. Practical significance

The practical significance of this study: the pile is hammered to a depth that does not require the stump of the pile head, as in the case of a micro-pile construction with the help of a mini pile driving machine, breaking down the pile head. Since the piles are made of reinforced concrete, and the top grill is installed, the possibility of corrosion of the reinforcement metal is excluded. The pile is made directly on the construction site, which will reduce the cost of production. So, with a diameter of 120
mm and a length of 1.5 m and an average cost of concrete + worker, 4000 rubles / m³, the cost of one pile will be 450 rubles.

6. Implementation results

The work was done at the address: City Voronezh, Street Sirenevaya, House No 1 (strengthening of the slope) and House No 21 (reinforcement of crash foundations, slope, see figure 8); Voronezh region, Novousmansky district, Repnoye village, street Lapshova, House No 27a (reinforcement of bottom soils under foundations); City Voronezh, SNT “Dubrava”, site 265 (construction of foundation).

Thus, the task of strengthening the landslide slope was solved with the help of calculations made by A. Abdulloev (VSTU, Department of BCB&F), using voluminous cementation of soils due to the possibility of landslides [13-16].

7. Conclusions

1. The construction of micro-piles helps to reduce the material consumption by 3 times, increase labor productivity, 3-5 times lower the cost of the construction of foundations in low-rise building;
2. use of this technology will expand the possibilities of construction;
3. The foundation of micro-pile foundations is ecologically safe, as the process does not include harmful waste, the use of noisy machinery and reduces energy costs for the production of a unit product (foundation).

At the department of Building Constructions, Bases and Foundations named after Professor Yu.M. Borisov, of the Voronezh State Technical University, further developments are underway, which will increase the use of micro-piles in a modern building complex.

References

[1] Stepanov M.A. 2002 Interaction of the combined band pile foundations with a preliminary bottom soils. VAK 05.23.02.
[2] Mayanov E.P., Shishkin V.Ya., Konusevich V.I., Elizarov G.P., Chesnokov G.V. Innovative technology of the construction of printed piles manufactured in the soil by the method of indentation. Internet-journal “Naukovedenie”. Moscow: Izd. Center “Naukovedenie”
[3] K. Feinstein 2018 Experimental research of an eccentrically loaded foundation. -Sb. Article V
of the International Scientific and Research Competition. Penza: MCSN "Science and Education" p. 226.

[4] Kolodyazhny S.A., Zolotukhin S.N., Abramenko A.A., Kukina O.B., Vyazov A.Yu., Lobosok A.S., Milovanova V.I. The method of manufacturing solid plate-like foundation of box section from ribbed slabs. Patent for invention No. 2647521. RF.

[5] Aleynikov S.M., Ikonin S.V. 1996 Control of foundation shape and loading parameters to preserve uniform settlement. Communications in numerical methods in engineering. Vol 11, pp. 745-753.

[6] Ikonin S.V., Suhoterin A.V 2015 The construction of a foundation plate with adjustable forces. Engineering and construction magazine. vol 3 pp. 10-20.

[7] Aleinikov S.M., Ikonin S.V. 1990 Three-dimensional deformation of the surface of a tapered elastic layer. Soil Mechanics and Foundation Engineering. vol 5 pp 218-222.

[8] Aleinikov S.M., Ikonin S.V. 1990 Spatial deformation of the surface of an elastic layer of variable thickness. Bases, foundations and mechanics of soils. vol 5 pp. 21.

[9] Fedorov I.V. 1962 Methods for calculating the stability of slopes and scarps. State Publ. literature on construction, architecture and builds. Materials.

[10] Esipov A.V. 2002 Interaction of micro-piles with bottom soil during the reinforcement of foundations - Ph.D. thesis. VAK 05.03.02. Scientific library of dissertations and abstracts disserCat.

[11] Veryuzhskii Yu.V., Ikonin S.V., Savitskii V.V. 1982 Application of the potential method in the calculation of rigid foundations. Bases and foundations. Budivelnky Kyiv. Vol. 15 Pp. 21-25.

[12] Yanina O.I. 2016 The question of geotechnical monitoring of buildings. Sb. articles of the International Scientific and Practical Conference. Penza, pp. 83-86.

[13] Zolotukhin S.N., Chigarev A.G. 2011 TECHNOLOGY OF VOLUME STABILIZATION OF SOILS. Scientific herald of Voronezh State University of Architecture and Civil Engineering. Series: High technology, Ecology. Vol. 1. Pp. 63-66.

[14] Zolotukhin S.N., Chigarev A.G. 2017 The issue of cementation of soils in the Voronezh region with the use of large-tonnage industrial wastes. Modern problems of engineering surveys in the central-chernozem region. Materials of the I regional scientific-practical conference. Edited by A.A. Auzin.

[15] S. V. Ikonin, M.S. Kim, A.V. Barannik, E.V. Tokarev. 1999 Design of reinforced cones of road embankments on approaches to bridges. - Geotechnics of the Volga region – 99. Coll. of works of Intern. Conf. on soil mechanics and foundation engineering - Yoshkar-Ola.

[16] A.I. Ananyin, M.S. Kim. 1999 Design of retaining walls using a finite-difference scheme. - Calculation and design of bases and foundations in a complex engineering geological conditions. Interuniversity coll. of scientific works, Voronezh.

[17] Solovev D. B. 2005 Determination of rational exciting currents in synchronous drives of quarry mechanical shovels Gorny Zhurnal vol. 3 pp. 70-73.