Investigation of Bearing Capacity of the Drill-Impact Micropiles with Enlarged Toe in the Soils of Different Type

Adam Podhorecki¹, Oleksandr Hnatiuk², Mykola Lapchuk², Oleksandr Mazepa³

¹UTP University of Science and Technology, Al. prof. S. Kaliski street, 7, 85-796 Bydgoszcz, Poland
²Lviv National Agrarian University, 80381, Volodymyr Velykyj Street 1, Dubliany, Ukraine
³PP BCF Osnova, 79038, Medovoji pechery street 38a/11, Lviv, Ukraine

podhorec@utp.edu.pl

Abstract. The reinforced concrete micropiles with enlarged toe is the effective construction for the arranging of new and reinforcing of existing foundations which a drill-impact method are made as a circular bar with a diameter to 250 mm from the flow consistency concrete with prefabricated reinforcement cage and enlarged to two diameters toe cone-shaped form. For research of them real work by the authors of the article and engineers of PP BKF “Osnova” were conducted them field tests on the objects of building in the different soil conditions and the analysis of them calculation and experimental bearing capacity is given. The analysis of quantitative correlation of experimental and theoretical bearing capacity for the different types of soils is the task of researches.

1. Introduction

The reinforced concrete micropiles with enlarged toe is the effective construction for the arranging of new and reinforcing of existing foundations which a drill-impact method are made as a circular bar with a diameter to 250 mm from the flow consistency concrete with prefabricated reinforcement cage and enlarged to two diameters toe cone-shaped form.

For research of them real work by the authors of the article and engineers of PP BKF “Osnova” were conducted them field tests on the objects of building in the different soil conditions and the analysis of them calculation and experimental bearing capacity is given [1].

The new effective construction of drill-impact micropiles from the reinforced concrete with enlarged toe developed on the department of build constructions Lviv national agrarian university and introduced in the real building. The experimental studies of them bearing capacity is given [2-4].

The actual values of drill-impact micropiles bearing capacity, what certain experimentally a method them the field tests the static pressing, mainly exceeds them theoretical values, got a calculation after norms [5]. The analysis of quantitative correlation of experimental and theoretical bearing capacity for the different types of soils is the task of researches.
2. Methods of experimental researches

The experimental field tests of 25 full-scale experimental samples of drill-impact micropiles with enlarged toe was given on the real objects of building and reconstruction of industrial and civil buildings with the purpose of verification of them work reliability.

Research of bearing capacity of of drill-impact micropiles of diameter 175÷250mm from the reinforced concrete with enlarged toe diametrom of diameter 350÷450mm is given. This affords the possibility of comparison of their work depending on:

- pile parameters (diameter of pile, diameter of enlarged toe, length);
- engineer-geological conditions.

The field tests of micropiles under the action of the vertical load were made with the purpose of experimental verification them bearing capacity and deformability of soil base at the level of enlarged toe by the method of the static pressing [6].

The complete equipment for testing included: pumping station HCP-400, hydraulic jack for loading, sprung design to resist a reactive loads by jack on a metal beam and 2 anchor piles (4 anchor piles sometimes with appropriate justifying calculations), benchmark systems and measuring equipment for displacements piles and anchors heads (figures 1, 2). The sprung design consisted of a 2 resisting and 2 distribution (in the case of 4 anchor piles) metal beams, that joint by means of bolts for mounting.

![Figure 1](image)

**Figure 1.** The micropile field test experimental equipment with four anchor piles: 1 – experimental pile; 2- anchor piles; 3 - anchor reinforcement bars; 4 - hydraulic jack; 5 - resisting beam; 6 – distribution beam.
All elements of sprung system have been designed, engineered and manufactured to the load, which is 20% higher than the prescribed program of research value. Equipment for loading micropiles ensure its central application of some uniform degrees.

Piles for testing was made in the pre-manufactured auger drilling borehole of diameter 175, 200 and 250 mm. The enlarged toe of diameter 350, 400, or in some cases 450mm arranged a special knife devices at the lower end of the borehole.

Foundation pour executed flow consistency concrete class C16/20 - C20/25, reinforcement - prefabricated cage with longitudinal reinforcement bar 4Ø12 A400C. Similarly anchor piles were made, each of them was additionally installed reinforcement bar diameter of 30mm for fixing metal beams of sprung design.

The tests of micropiles was made under the action of the monotonous way stepwise increasing vertical. The load on the pile applicated evenly, without shocks, the degree of loading, the value of which was set test program, but no more than 1/10 of a given program the largest its value.

Jack pushing force was identify by the manometer data of pumping station. Before the tests necessarily jack on the hydraulic press, which took control of ocular believe.

![Figure 2](image_url)

**Figure 2.** A conducting of experimental researches of micropile bearing capacity on the object of building of foundations on a street Kozatska, 18, in Lviv (soil of basis is gruss of sedimentary rocks).
The settlement of micropiles by two Aistov system deflectometer with value point 0.01 mm are measured, which located in two diameter opposite points of section micropile upper end. Drawing out of anchor piles was measured Maksimov system deflectometer with value point 0.01 mm.

Loadings of model pile on every degree were indexes on all devices for measuring of settlements in such sequence: zero index – before loading of pile, first counting out – at once after loading, then gradually four indexes with an interval 30min and next through every hour to the conditional stabilizing of deformation (fading of deformation).

The criterion of subjunctive stabilization field tests of real piles accept the loading speed no exceed 0.1 mm at the time: last 60 min observation, if sandy or clay soils from hard to tough consistency lie under the bottom pile end, last 2 h observation, if from soft to fluid consistency clay soils lie there.

Loading at a test come up to the value, at which the general settling of micropile was made by not less than 40 mm. At embedment of bottom pile end in macrofragmental, dense sandy and clay soils of hard consistency the loading come up to the value which was foreseen the program of tests, but not less than a 1.5 value of micropile bearing capacity, which was determined a calculation.

3. **Comparison of the experimental and calculated measures of micropal bearing capacity**

The calculation value of bearing capacity and possible loading for the probed micropiles accepted after a method addition of H [5]. Into account part of loading, which was perceived the main bearing layer as a percentage of the estimated bearing capacity of the primary and the other layers of the soil base, was accepted.

It was set as a result of analysis, that ratio of the calculation and experimental possible loading on piles, reduced to the main base layer made:

for semirocky soils (rubbly soil and gruss $R_0=400-450$ kPa) – $1.8\div2.04$;
for fine sands ($e=0.56\div0.69$) – $1.02\div1.14$;
for middle-sized (medium-grained) sands ($e=0.61\div0.66$) – $1.66\div2.0$;
for sandy loams plastic ($I_L = 0.31\div0.67$) – $1.36\div3.12$;
for loams tough and hard ($I_L = 0.2\div0.5$) – $2.1\div3.9$;
for clays hard and semihard ($I_L = 0.25$) – $1.38\div2.18$.

4. **Conclusions**

The experimental tests of new effective constructions of drill-impact concrete micropiles with enlarged toe with high bearing capacity, minimum expense of materials and simple technology of their making and arranging in the different soil conditions was given.

Analysis of experimental and certain in theoretical information show that in all cases the experimental values of bearing capacity and experimental possible loading on micropiles exceed a calculation. The mean value of relation of the calculation and experimental possible loading on piles made for semirocky soils 1.86, fine sands – 1.1, middle-sized sands – 1.85, sandy loams – 2.38, loams – 3.52, clays – 1.61. Consequently, the nearest are values of theoretical and experimental bearing capacity for fine sands, and a calculation value is most underestimated for sandy loams.

Got as a result of experimental and theoretical researches information, given in the article, make it possible to estimate the real bearing capacity of drill-impact concrete micropiles with enlarged toe.

**References**

[1] PP BCF Osnova [Online] 2021. Available at: http://pposnova.lviv.ua.
[2] Declarative patent for invention № 2003109615, Ukraine. Buronabyvna mikropalia z posshyrenoju p’yatoiu. Hnatiuk O. T., Mazepa O. M., Onyskiv B. M. (Ukraine). – publ. 26.05.04, Biul. № 5, 2004 (in Indonesian).

[3] Declarative patent for utility model № 1824563789, Ukraine. Poshyriuvach sverdlovyn dla buronabyvnych zalizobetonnych mikropali. Dobriunskyj I. M., Vankevych P. I., Hnatiuk O. T., Mazepa O. M., Onyskiv B. M. – publ. 26.03.05, Biul. № 3, 2005 (in Russian).

[4] Rezultaty eksperymentalno-teoretychnykh doslidzhen kushchiv buronabyvnych mikropal pry diji horysontalnykh navantazhen/ I.M.Dobriunskyj, O.T.Hnatiuk, M.A.Lapchuk, O.M.Masepa, P.F.Kholod // Haluseve mashynobuduvannia, budivnytstvo: zb. nauk. prats / Poltav. nats. techn. un-t im. Jurija Kondratiuka. Vyp. 3 (38). – Poltava: Polt.NTU, pp.120‒127, 2013 (in Russian).

[5] DBN V.2.1-10-2009. Osnovy ta fundamenty budivel ta sporud – Kyiv: Minregionbud, p. 161, 2009 (in Russian).

[6] Grunty. Metody poliovykh vyprobuvan paliamy: DSTU B V.2.1– 95 (GOST 5686-94). – Kyiv: Ukrarkhbudinform, p. 57, 1997 (in Russian).