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Micropiles in Poland

Micropiles are used for:
⇒ underpinning and new structures,
⇒ protection of slopes and excavations.
The typical dimensions are:
⇒ diameters from 100 to 180mm,
⇒ fixed length from 4 to 10m.
The bearing element consists of:
⇒ one or few steel bars,
⇒ more often steel tube 60 to 140mm diameter,
⇒ steel I or H section.

Typical design loads of compressed micropiles are from 200 do 700kN, but may be higher than 1000kN. **Preloading** is used to reduce settlements. Tension micropiles are seldom applied.
Micropiles most often are bored, with drilling mud or casing, and grouted (minimal pressure 0.5MPa) or post-grouted. The Titan Micropiles are also used.

The CFA-micropile 300mm diameter, formed by means of a hollow stemmed continuous flight auger and pressure post-grouted using tubes or plastic hoses - very effective, high bearing capacity as well as axial and lateral stiffness.
Jacked and jacked-and-grouted micropiles sometimes are used.

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AXIAL MICROPILE STIFFNESS

The micropile stiffness K_m = ratio of axial force Q to settlement s_m.

This parameter is used particularly in analysis of interaction of micropiles and strengthened foundation. The stiffness K_m depends on many factors: deformability of ground, concrete section area, reinforcement, shaft free length as well as on construction technique.

It is interesting to note that the stiffness K_m decreases distinctly with the load increase, while it does not much vary when the settlement increases.

Calculation of the stiffness K_m is difficult and not reliable. The analytical methods do not account for the specific construction process of micropiles. Useful data are obtained from a study of observations.

The results of 20 load tests of micropiles in various soils have been analysed. The piles were of diameters from 108 to 180mm, fixed (bearing) length from 4.0 do 9.0 m and two were ∅300mm CFA-micropiles. On the basis of this analysis, the typical micropile stiffness is in rather narrow range: from 50 do 200 MN/m and up to 400 MN/m for CFA-micropiles. There was no clear connection with loads. But there is rather regular relation with the settlement. The stiffness visibly decreases when settlement increases up to 5mm. For the higher values the stiffness decreases only slightly. The practical value of these data is that they are helpful in economical designing of foundations strengthening.

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Micropiles in Poland

General

Micropiles are constructed in Poland since 1985. They are used mainly to resist axial compressive forces, rather seldom tensile forces; in underpinning, for new structures and also for protection of slopes and excavations.

The typical dimensions are:

- diameters from 100 to 180mm,
- fixed length from 4 to 10m.

The bearing element consists of one or a few steel bars or more often of steel tube 60 to 140mm diameter. Also steel I or H sections are used. The Titan Micropiles are also applied.

Typical design loads of compressed micropiles are from 200 do 700kN, but may be higher than 1000kN. Preloading is used to reduce further settlements.

Micropiles most often they are bored, with drilling mud or casing, and grouted (for bearing micropiles a minimal pressure 0.5MPa is required) or post-grouted. Specific, very effective kind is the CFA micropile 300mm diameter (Fig. 1), formed by means of a hollow stemmed continuous flight auger and pressure post-grouted using tubes or plastic hoses. The bearing capacity of these piles as well as axial and lateral stiffness may be high.

Sometimes jacked and jacked and grouted micropiles are also used e.g. in a building cellar.

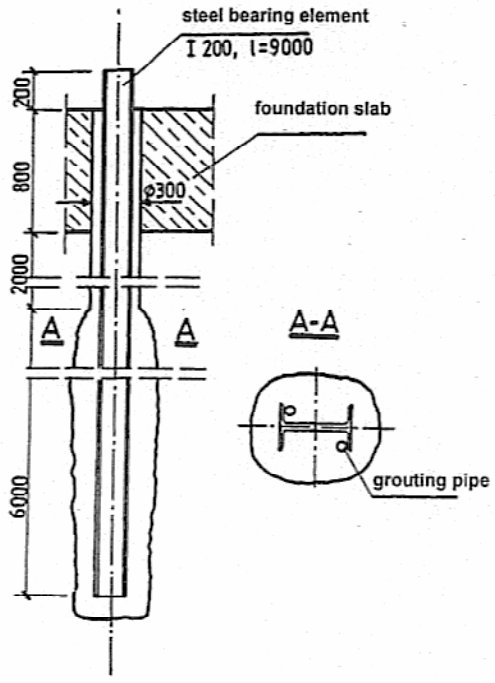

Fig .1. CFA micropile 300 mm diameter

Axial micropile stiffness

Usually a designing engineer is most concerned in bearing capacity of a micropile. It is very important because it control safety of a foundation. But in fact one considers not real values: factored (increased) design loading and factored (decreased) design bearing capacity. The real parameter is the axial stiffness of a micropile in range of working loads. It is particularly needed for analysis of a shallow foundation strengthened by micropiles.

Micropile stiffness K_m (secant), defined as the ratio of axial force Q to settlement s_m, is a parameter used particularly in analysis of interaction of micropiles and underpinned existing foundation. The stiffness K_m depends on many factors: deformability of the ground, concrete section area, reinforcement, shaft free length as well as on construction technique.

It is interesting to note that the stiffness K_m decreases distinctly with the load, while it does not much vary when the settlement increases. It is illustrated in example of a micropile behaviour shown in Fig. 2.

Błąd! Nieprawidłowe łącze.

Fig. 2 Examples of variation of the micropile axial stiffness Km
(Micropile 150mm dia. L = 8.5m)

Calculation of the stiffness K_m is difficult and not accurate. The analytical methods do not account for the specific construction process of micropiles. Useful data may be obtained from analysis of loading test data.

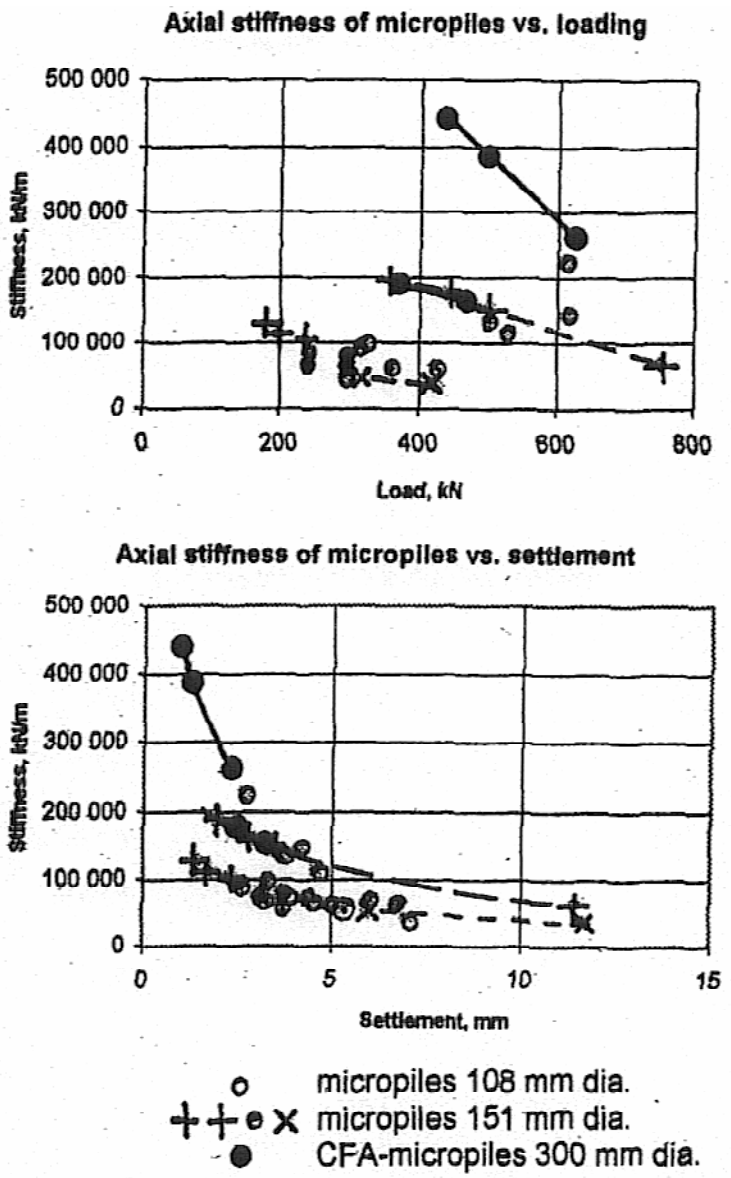

Fig. 3 Variation of axial stiffness Km of micropiles

The results of 20 load tests of micropiles in various soils in Poland have been analysed. The piles were of diameters from 108 to 180mm, fixed (bearing) length from 4.0 do 9.0 m and two were ∅300mm CFA micropiles. The results are given in Fig. 3. On the basis of this analysis, the micropile stiffness is typically in rather narrow range: from 50 do 200 MN/m (only up to 400 MN/m for the CFA micropiles). There was no clear relation with loads. But there is rather regular relation with the settlement. The stiffness visibly decreases when settlement increases up to 5mm. For the higher settlement values the stiffness decreases only slightly. The practical value of these data is that they are helpful in economical designing of foundations strengthening.

Design of foundation strengthening

In a strengthened foundation part of load is borne by an existing plate or footing, and part by a "mixed" foundation including the micropiles. For typical pile foundation it is assumed that the full load is carried by the piles. In case of the already loaded foundation its interaction is usually evident, particularly when the footing is large.

Portions of the load acting on the footing and the micropiles result from analysis of their stiffness. Most often simple approximate solutions are used, similar as for piled foundations. The typical examples are shown in Fig. 4. More detailed analysis needs summation of the soil stresses from the footing and the micropiles, and their interaction. For such analysis sophisticated computing programs would be necessary.

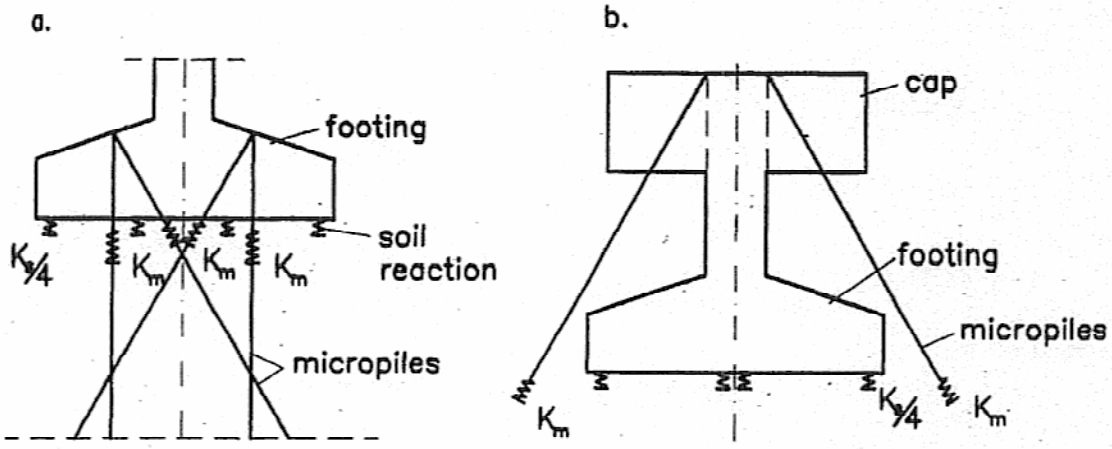

Fig. 4. Design schemes of foundation footings strengthened by micropiles

There are many methods for conventional pile group design, in which bearing capacity of a pile in group is reduced or settlements are increased. E.g. Converse-Labarre empirical(?) formula or well known elastic solution by Poulos. In case of micropiles the situation is different. There are evidences that interaction of micropiles in a group has beneficial effect on their capacity and reduces their settlement. This view is supported by model tests (Lizzi and Carnevale 1979) and also field tests e.g. Plumelle (1984) who had obtained smaller settlements and higher capacities in the case of inclined micropiles. The correct answer is not known yet. This problem needs further research.