DESIGN

FOUNDATIONS WITH MICROPILES IN TAMPED TRENCHES
ON CONSTRUCTION PROJECTS IN BELARUS

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A procedure is presented for the installation of foundations with micropiles, a distinguishing characteristic feature of which is the tamping of a trench and its concreting with a group of micropiles under an embedded grillage. A set of field investigations under different soil conditions, which has indicated the reliability of these foundations and their effectiveness for the construction of any buildings and structures, is described.

Since the mid-1980s, foundations in compacted soil [1, 2, and others], especially with micropiles in tamped trenches (FWM) has come into widespread use in Belarus [3]. The principal difference in the procedure that we developed is the tamping, and then the concreting of a group of micropiles and trench beneath an embedded grillage. A segment of prepared foundation is a monolithic structure consisting of a grillage, which is supported on several micropiles (usually three or four), which are situated in a compacted soil core. More than 300 industrial, civil, and agricultural buildings have been raised. As compared with strip and columnar foundations on an undisturbed bed, 130 kg of cement, 25 kg of metal, and 1.5 man-days of labor are saved per 1 m³; this is greater than in the case of foundations in tamped trenches for which these indicators are, respectively; 80 kg, 20 kg, and 1.2 man-days [4].

The Belarus of the Scientific-Research Institute of Construction has conducted a set of studies required for the implementation of FWM in construction practice, which includes development of the following:

1) working drawings and the fabrication of punches/hole shapers, which are adapted for embedment and withdrawal from the ground by standard pile-driving equipment (Fig. 1);
2) production schemes for the installation of FWM in various soils with the output of type flow sheets for different types of buildings and structures; and,
3) principles for the design and calculation of beds on the basis of experimental studies with the publication of appropriate standard literature [5, 6].

The punch/hole shaper is sectional and contains a grillage punch and a micropile punch connected to it via a flexible link (Table 1).

We developed a series of these punches, which make it possible, combining their number and bearing capacity, to eliminate foundations beneath linear loads of from 100 to 1000 kN and concentrated loads of from 400 to 5000 kN with allowance for the magnitude and direction of the moments and horizontal loads.

Examples of hole arrangement in foundations are presented in Fig. 2, and schemes for structural solutions of FWM installation in Fig. 3.

When tamping one hole for a single foundation, the work is performed by a single punch with subsequent driving and withdrawal at each new point of the foundation. When a group of holes is punched (including discontinuous strips), a set of punches (two, three, or four) are used so as to provide sheltering (protection) of fabricated piles away from the driving site against punches embedded in the ground.

Complex field investigations of beds under various soil conditions were conducted during construction. A total of more than 70 static tests were performed on single FWM under an axial penetrating and inclined load, which indicated their high specific bearing capacity (Table 2), including in gravelly sands, where measures were specified to prevent collapse of
the walls of the holes. FWM segments were tested in these soils, and also in sands of medium fineness under a load of 5000 kN with subsequent observation of settlements of full-scale foundations and their comparison with results of field tests (10 - 20% error).

It is precisely the high specific bearing capacity that is the reason for the high economic effectiveness and reliability of FWM. The increase in the specific bearing capacity is associated, however, with the development of a zone of compaction of bed soils as the punch penetrates into them. In that case, a single pile-soil mass in which the micropiles are vertically reinforcing bearing elements develops beneath the grillage of the foundation.

To study the formation of the compaction zone, we exposed 12 experimental FWM with layer-by-layer determination of the physico-mechanical characteristics of the bed soil by the split-ring and dynamic-penetration methods. A total of 780 measurements were taken. The results of studies of the compaction zone (assuming the shape of an ellipsoid of revolution) made it possible to establish its parameters for sandy soils, which were as follows in the broadest section: (3.92-4.2)B with respect to width and 1.62B with respect to depth for dense sands, 2.8B with respect to width and 1.8B with respect to depth for sands of medium density, and 2.24B with respect to width and 2.96 B with respect to depth for loose sands, where B is the width of the FWM.