Field and experimental investigations as well as full-scale tests of foundations and artificial bases in punched (tamped-out) trenches at specific projects in South Kazakhstan have once again confirmed the effectiveness of their application in seismic regions with similar soil conditions.

The southern region of Kazakhstan corresponds to seismic zones of magnitude 7-9. Construction in this region is additionally complicated by predominance of soils of type I and II collapsibility.

Study of the national experience has shown that in seismic regions use has been successfully made of foundations in punched trenches (FPT) since the seismic properties of the bases are improved, especially when there is subsequent tamping in them of soils with better physicomechanical characteristics, that is, by construction of punched earth pads (PEP). Nevertheless, in South Kazakhstan only traditional solutions continue to be applied which call either for complete replacement of the base soils or for construction of pile foundations, which significantly increases the construction cost.

For wider FPT and PEP use in South Kazakhstan, the Alma-Ata Integrated Branch of the Spetsfundamentstroial NPO Association jointly with the Kishinev Branch of the NIIOSP institute carried out investigations on full-scale foundations and bases at several construction sites.

Trench punching was performed by a UVK-40 installation fabricated at an experimental mechanical shop of the "Spetsfundamentstroial" NPO Association. The UVK-40 equipment consists of an RDK-25 crane whose jib has a 15-m high guide mast. At levels of 6, 9, and 12 m, the mast has levers for automatic drop of an 8-ton rammer from the established height (Fig. 1).

The FPT was prepared in the following order: placement of the installation over the foundation axis; punching of the pioneer trench to a depth equal to 0.5H (in which H is the design depth of construction of the foundation); soaking of the soil to the optimal water content (as required); punching of the trench to the design elevation; tamping in the trench bottom of 1.5 m$^3$ of rubble; installation of the reinforcement cage (eight bars 16 mm in diameter and 3.5 m long); and concreting of the foundation with V-10 concrete (the reinforcing bar projections were embedded to 400 mm into the cap).

For construction of a paired foundation, punching of the second trench was carried out before start of setting of the concrete mix placed in the first trench.

The PEP construction technology includes the following operations: placement of the installation over the trench axis; punching of the pioneer trench to a depth equal to 0.5H; soaking of the trench with water to the optimal water content (as required); punching of the trench to the design elevation; tamping of 1.5 m$^3$ of rubble in the trench bottom; placement of rubble fill in the trench with layer-by-layer tamping; complementary compaction of a buffer layer using the same rammer, with rubble tamping; cutting of the top layer of the soil to a depth of 0.15 m.

Test work was carried out at three sites occurring under different soil conditions characteristic for the region being considered.

Site No. 1 was located in the area of construction of the main building of the Alma-Ata Factory of Wall Components. As regards the geologic-lithologic morphology, it consists of aeolian and lacustrine—alluvial deposits represented by an interbedded mass of sands from silty to gravelly with gravel lenses. The underlying soils are clays and loams of the Neocene. The coefficient of permeability according to pumping-out data is 8.2 m/day. The soil characteristics are presented in Table 1. In the base of the foundation to a depth of 3 m there is dense gravelly sand. In this area two foundations were constructed in punched trenches F-1 and F-2 at a depth of 3 m.

Site No. 2 was located in the area of construction of the production shop of a reinforced-concrete products plant in the city of Kapchagai, located in the place of a former quarry filled to a depth of 3-4 m with fine-grained wet sand. Disturbance of the quarry filling technology determined the following physicomechanical soil properties: \( \rho = 1.45 \text{ tons/m}^3; \ e = 0.7; \ s = 0.5; \ c = 0; \ \varphi = 28^\circ; \ E = 18 \text{ MPa} \). The underlying material consists of fissured rocky soil. At this site, three foundations were constructed in punched trenches F-3, F-4, and F-5. Each foundation consists of two paired FPT's located at a distance equal to \( 2b_{mn} \) (in which \( b_{mn} \) is the width of the mean section of the rammer) from each other and joined by a cap. For the project it was necessary also to determine the effectiveness of use of punched trenches filled with hard material (sand—gravel mix) as base under the column foundations; for this reason three PEP-P1, P2, and P3 pads were constructed.

The advisability of construction of PEP's under strip footings was to be verified at site No. 3, located in the construction zone of a nine-story residential building in Alma-Ata. The construction site consisted of clayey soils of Type I collapsibility up to 6 m in thickness with the following physicomechanical properties: \( \rho = 1.9 \text{ tons/m}^3; \ \rho_d = 1.5 \text{ tons/m}^3; \ e = 0.8, \ c_n = 0.07 \text{ MPa}; \ \varphi = 17^\circ; \ E = 7.4 \text{ MPa}; \ f_L = 0.2 \). The underlying material was a gravelly soil layer 4-6 m thick with sand filler up to 46% of medium size, dense.

The original project called for excavation of the collapsible layer throughout the entire depth to the gravelly soil and its replacement by a 3-m-thick sandy—gravelly mix (to the strip footing underside level). Three PEP-P4, P5, and P6 pads were constructed. In contrast with former projects, the punched trenches were prepared without widening, applying uniform tamping of boulder—pebble material over the trench height.

A special characteristic of the carrying out of construction of the FPT's and PEP's in sandy soils was the ensured stability of the trench walls over the entire work cycle; hence, for sites Nos. 1 and 2, special attention was devoted to the water content of soils having a natural water content less than the optimal. The water quantity for the soaking process was determined in accordance with Handbook [1]. Soaking of the soil was carried out during the construction work, and for the FPT and PEP tests use was made of tanks installed at the sites and equipped with distributing hoses and flow meters.

The performed work showed that the punching quality depends to a considerable extent on the water content of the sandy soil and the rammer blow energy.

The foundations and bases in the punched trenches were tested 30-50 days after completion of the work of soaking the soil to the water-saturated state. For the tests use was made of a stock surcharge platform and a support-anchor stand equipped with DG-200 and DG-100 jacks. The platform, loaded by foundation blocks, transmitted the load to the plates through five steel rollers 70 mm in diameter each. A horizontal force was applied along the foundation axis 20 cm below the cap.