CONCRETE-PIPE PILES IN BASE OF TALL BUILDING

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The writers present design and construction experience with foundations of a tall building on concrete-pipe piles under complex engineering-geologic conditions. Results of static tests on the piles are compared with the stabilized settlements of the building foundations. It is established that their values are close to each other.

In foreign countries, under complex engineering-geologic conditions tall buildings are frequently constructed on concrete-pipe piles using steel or reinforced concrete shells left in the soil. For example, in Great Britain, such piles are successfully constructed by the "British Steel Piling" Company. In the former USSR, there were many well-known examples of use of concrete-pipe support piles in bridge construction.

Of great interest is the experience with design and construction of pile foundations of the unique 28-story building of the Kiev Data-Processing Center of the Ukrainian Civil Aviation Administration on Pobeda Prosp., 4-6 (Fig. 1).

According to data from engineering-geologic explorations carried out by the Ukrainian State Institute of Engineering—Technical Explorations, the construction site to an investigated depth of 30 m consists of Quaternary deposits. The geologic-lithologic section (from the top downward) is characterized by the following data: water-saturated fine sand with sandy loam interlayers 3.1-8 m thick; sandy loam with thin interlayers of fine and silty sand in a flowing state, 1.8-13.8 m thick; stiff-plastic loam in the form of lenses in a 0.6-0.9 m sand mass; water-saturated medium sand in a 1-6.8-m-thick layer, lying at a depth of 14.6-20.8 m, at some places with gravel and pebble inclusions; stiff-plastic loam in a 2-6.2-m-thick layer lying at a depth of 14-22 m; spondylous clay (Kiev marl) of semihard consistency, with its roof at a depth of 22 m (in the intervals between the holes, it could be lower by 1-2 m).

With the writers' cooperation, the KievZNIIEP designed the foundations of the tall part of the building in the form of a pile field with a continuous reinforced concrete mat and crossed beams along the longitudinal and transverse rows of metal columns. The concrete-pipe piles are arranged in a checkered order, at spacings of 2.4-2.6 m. The steel shells (pipes), 22 m long, are 820 mm in diameter. In its top portion, the pile shaft is reinforced with a 7-m-long cage.

From the depth conditions of the 1800-mm-diameter widened base in the spondylous clay below the steel pile, it was contemplated to drill a 780-mm-diameter hole. The design load on the pile without taking into account its dead weight was initially determined as 3000 kN.

To work out the technique for construction of the concrete-pipe piles and to verify their bearing capacity experimental specimens were constructed which were tested under a static compressive load (Table 1).

It should be noted that the bearing capacity of the pile is affected by the method of its construction and the fabrication time. An OS-1 steel-pipe pile was sunk into the soil by a VP-30 vibration-driver in sections, with the rock being drilled out by a 780-mm-diameter bucket drill. The pipe section joints were welded vertically without laps by V-shaped three-layer jointing by the inversely stepped method. During the process of sinking the pipe and drilling the soil without pouring water, boil of soil through the open lower end of the pipe was observed, and the ordinary ground surface descended around it. As soon as the lower end of the pile was driven into the confining clay layer, soil boil ceased. The hole below the pipe was drilled by a bucket auger 780 mm in diameter. After removal of water from the hole by means of an especially fabricated sludge pump with a spherical valve in the bottom center, the widening was "dry" drilled. The interval between completion of the drilling of the widening and start of concreting of the pile was about 3 h.
During construction of the OS-2 pile, water was not removed from the hole, and concreting was performed by the tremie method using a vertically moving pipe (VMP).

The method of drilling and concreting the OS-3 pile was similar to that applied for construction of the OS-1 pile. During the testing process, a relatively small load was obtained, and the test graph showed sharp variation of the curve characteristics in the portion from the limit to the critical value, which indicates the presence of a weak base capable of causing rupture or overbreak of the soil in the widening during concreting.

The method of construction of the OS-4 pile is more refined and intense. The interval between completion of drilling of the widening and start of concreting of the pile did not exceed 2 h. Water infiltration into the widening was not observed. For this reason, concreting was carried out "dry" by dropping concrete mix of Class V 22.5 (M-300) with a slump of 7-8 cm through a funnel with a concrete-pouring branch pipe. Lack of a sharp turn in the curve on the OS-4 pile test graph shows the presence under the widened bottom of a less compressible soil bearing layer than in the other test piles.

In the sites where the OS-1 and OS-3 pile test results showed insufficient bearing capacity, additional tests were carried out on working piles (RS-10 and RS-11) embedded into the spondylous semi-hard clay to 4 m, that is, deeper by 2 m than the test piles.

The RS-10 pile (near the OS-1) pile was constructed at an intense rate and without technical interruptions. Drilling-out of the widening and concreting were carried out "dry."

The RS-11 pile (next to the OS-3 pile) was constructed with some interruptions during drilling under the usual water pressure. Complete removal of the water before concreting was not feasible. Concreting of the widening started when the water layer height was 0.5 m using M-300 concrete mix with a 3-5-cm slump. Subsequently, the shaft was concreted with M-200 mix having a 7-8-cm slump.

From the results of the tests on the experimental and working concrete-pipe piles with 1800-mm diameter widened bases resting on the spondylous clay at a depth of 27-28 m, a maximum design load of 3500 kN was adopted for each pile in the foundations of the tall part of the building.

Fig. 1. 28-story building constructed on concrete-pipe piles.