CONSTRUCTION ON PERMAFROST SOILS

MULTIFUNCTIONAL COMBINED FOUNDATIONS ON PERMAFROST SOILS

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The writers examine the construction of multifunctional combined foundations on permafrost soils, as approved for strengthening the foundation system of an administrative—industrial building in Norilsk. Such foundations make it possible to control the building deformations developed as a result of increase in the pile loads or in the settlements of the piles due to decrease in their bearing capacity when the soil base temperature increases.

One of the basic causes of failure of components of buildings constructed on friction frozen piles is the development of deformations due to variation or disturbance of the temperature regime of frozen soils, which leads to loss of bearing capacity of the soil base. In this connection, reconstruction of deformed building components and foundations by application of ordinary constructional solutions and traditional strengthening methods is of low effectiveness and very costly.

However, this can be prevented by providing for the possibility of controlling the deformations during the process of construction and operation of the buildings, using the multifunctional combined foundations developed by the writers. These are foundations on natural soil bases, constructed jointly with the piles and with a ring which ensures their independent displacement under loading.

Under complex permafrost-soil conditions, these foundations should perform the following functions:

1) Redistribute the loads acting on the pile and foundation on the natural soil base during the process of construction and operation of the structure for optimal utilization of the bearing capacity of the soil bases;
2) Control the deformations in the case of variation of the foundation operation conditions;
3) Stabilize the settlements, for insufficient bearing capacity of the soils on which the piles rest;
4) Restoration of sinking superstructures to the design position.

Figure 1 shows the construction schematic of such a foundation, built in the following way. Around each of the foundations being strengthened, trenches are excavated whose depth is at a depth of 1 m below the limit of seasonal freezing—thawing. Subsequently, around the pile a casing of anisotropic material is formed whose height is equal to the trench depth. The casings may consist of a wooden box subsequently clamped with tie rods or collars, wrapping the pile with sheet metal or rubberoid (3-4 times), glued to hot mastic, etc. On the trench bottom, crushed stone is placed which is saturated with asphalt binder, and formwork is instalalaed under the ring and the reinforcement. The lower surface of the existing pile cap is coated with hot asphalt, and packing made from insulated material (ruberoid, parchment, polyamide, resin, etc.) is formed. Subsequently, the base of the foundation and the ring columns is concreted, the recess in the top portion of the ring and along its external perimeter being constructed coaxially with the pile in the boundary centers. The recess dimensions must ensure installation of the jack. After the concrete has attained the required strength, the foundation formwork of the foundation is removed, and it is coated with hot asphalt for waterproofing. The trench recesses are filled with soil, which is then compacted. The presence of the ring with a gap with respect to the pile ensures its independent reciprocal operation, as a result of which there is redistribution of the loads acting on the structure. The ring takes and transmits to the soil base only vertical loads, whereas part of the vertical loads and all the horizontal loads are fully transmitted by the pile rigidly secured to the cap.
To prevent or eliminate the building deformations caused by settlement of the foundation when the load increased or the piles settled as a result of increase in the temperature of the frozen soil or even of its thawing, etc., the jacks are installed in a recess and the soil is compressed in the base of the ring by the amount of the calculated or possible settlement. The jacks are disconnected and dismantled. When the foundation settlement reaches a value equal to the calculated stabilized settlement caused by the structure load under varying conditions, in the gap formed between the two parts of the foundation (∆S₂), reinforcement is placed and concrete is poured. If required, the operation can be repeated without substantial costs and with low labor-consumption.

The proposed method was applied to strengthen the foundations of the Administrative-Industrial Building of the Equipment Replenishment Board (ERB) in Norilsk. The building is located in the area of thermoelectric plant No. 1 (TETs-1) on the Norilsk-Talnakh highway. The building foundations were designed and constructed in accordance with principle 1 as friction frozen piles.

The building has undergone significant deformations due to degradation of the permafrost soils in the base as a result of the thawing action of a sewer passing under the building and of brooks flowing under the fill and fed by the thermoelectric plant industrial water. At the present time, two zones have been formed under the building: zones I of thawed soils, and II of high-temperature frozen soils. The measures previously adopted to prevent development of deformations and further increase of the soil temperature (construction of a frozen-soil curtain in the brook area by means of Freon cooling installations, strengthening of different portions of the building, etc.) did not yield a substantial effect; for this reason the need arose for carrying out foundation-strengthening work.

Figures 2 and 3 present analytical schemes of the foundations and lithologic sections of the "ERB" site in zones I and II.

In zone I, during thawing of the permafrost base material, the soil around the piles are consolidated with time, as a result of which the load on the pile is transmitted along its external outline (the pile diameter is 530 mm for Type NS-32 and 630 mm for Type NSF-40).

On this basis, the bearing capacity of the existing foundation in this zone was determined by friction along the soil in the thawed loams and clays, and in the frozen portion starting from E1.50 m by freezing-together of the lateral surfaces of the piles and the clays, as well as by resistance to the pressure on the frozen soils under the pile ends. In this connection, as analytical temperature is was made of a maximum value equal to minus 0.3°C.