Organization and technology of the construction on the weak and water-saturated soils

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Abstract. Organizational and technological solutions have been developed for the production of the underground part of a capital construction facility on weak and aquiferous soils in extremely cramped conditions. The main technological operations for the arrangement of protective measures are considered. The following tasks were formulated and solved: - rational anti-landslide activities were defined; - ways to preserve the performance properties of existing buildings and structures were defined; - technological solutions to strengthen the soil array of foundations and foundations of closely located buildings and structures are proposed; - a rational way to develop the soil in the pit is proposed.

1 Introduction

In the large population generation centers, the field observations show a dense layout of the above-ground space [1]. Therefore, in order to increase the useful area of a construction object, a person actively explores underground space. The conditions of the surrounding buildings dictate the limitations of the area of new objects and, consequently, the area of the construction site in such a way that the distance to adjacent structures doesn't exceed 10 m. [2]. Currently, the construction of buildings with a developed multi-level underground space is relevant. The most common are buildings with a frame structural scheme, often made of monolithic reinforced concrete. One of them is the object, which considered.

There is a three-level underground space in projected building. The underground part of the building is arranged in a pit with a depth of 12.2 m. The enclosing structures of the underground part are made of monolithic reinforced concrete. Taking into account the data of geological and hydrogeological surveys [3], a foundation plate with a thickness of 1000 mm is chosen as the foundation, and the foundation for the pile foundation is made of bored piles up to 30 m long and with a diameter of 1 meter.

2 Materials and Methods

The estimated area of construction is characterized by a high level of soil, which is caused by the location of the area in the floodplain of two rivers. The geological structure of the construction site is represented mainly by sandy soil. With these characteristics, the design of technology and organization of underground construction requires a science-based

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approach. In this regard, develop an organizational and technological solution for the construction of the underground part of a capital construction object on weak and water-saturated soils in the limited space of the urban environment is aimed of this work. (Fig. 1).

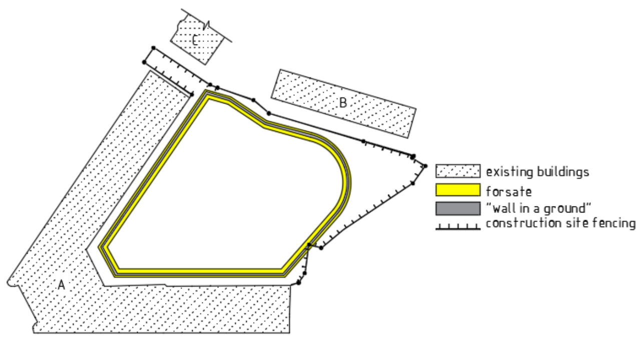

Fig. 1. The layout of the existing buildings and the boundaries of the construction site.

At the design stage, it is necessary to take the measures to ensure the safety of underground utilities and supporting structures of existing construction projects that fall into the zone of influence of new construction. For this purpose, first of all, information is collected on geotechnical and hydrogeological surveys of the construction site and on existing buildings and structures. Taking into account the data obtained, the boundary of the zone of possible impact of new construction [4, 5] and communications and supporting structures of existing construction objects that fall into it are determined and they are examined. In the project under consideration, this zone partially covers the existing buildings A, B and C. Before work on the construction of a new facility, it is necessary to take measures to protect the surrounding building from excessive deformations [4]. These activities involve the execution of works to strengthen the foundations of existing buildings as well as the stabilization of possible drafts. Designed building is surrounded by existing buildings with different types of bases and foundations. This fact must be considered when strengthening them. The building, which borders the projected object from two sides, has a pile foundation (building A, Fig. 1), combined with a monolithic reinforced concrete grillage. Strengthening of this building is proposed to be done by fixing the soil under existing piles using inkjet technology (Fig. 2) [6,7].

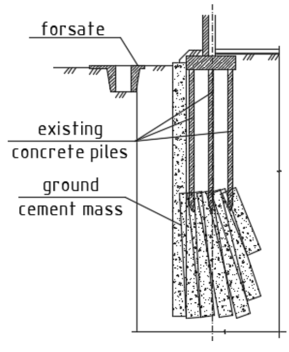

Fig. 2. Strengthening the foundations of the building A.

The use of this method contributes to the transfer of the load from the building to the level below the bottom of the foundation pit by increasing the strength and deformation characteristics of the foundation soil under the tip of the piles. At the same time, deformations of the base of the building being strengthened are reduced and pressure on the building envelope of the new building is reduced. The upper boundary of the zone of a fixed soil mass is located at a mark 1 m above the mark of the location of the bottom of the existing driving piles. The lower zone of consolidation of the soil mass is located at a mark of 6 m below the mark of the location of the bottom of the existing driving piles. The diameter of the zone of consolidation during the formation of a single cement-soil column is ø800mm, the pitch of the holes of the fastening is taken from ensuring the continuity of the fixed soil mass. In accordance with the requirements of [8], the first scheme of soil consolidation was chosen by creating a continuous array. To minimize the impact of the new construction of the building B and C (Fig. 1) of the partition wall (Fig. 3, 4), an apparatus is provided on the side of existing buildings as a sheet piling formed of hollow metal pipes. The sequence of works on the wall device is shown in the block diagram (Fig. 3).

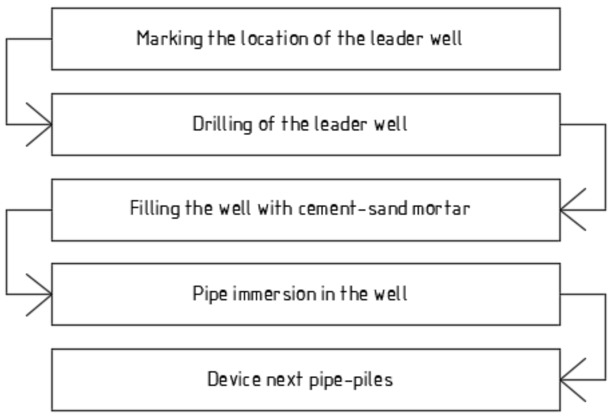

Fig. 3. The block diagram of the production work on the device dividing wall.

The well is drilled with hollow screws to the design mark.

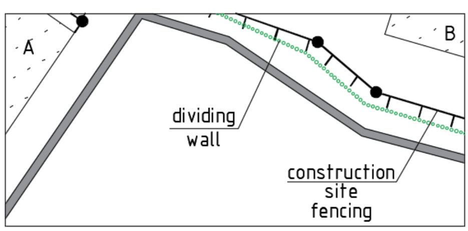

Fig. 4. Detail of tube piles and location of soil grouting.

For the device of the underground part of the building, the development of a foundation pit slab is planned. However, in the specified geological conditions, taking into account the constraints of construction, the walls of the pit may collapse at the production stage. To eliminate the collapse of the proposed device "wall in the ground" around the perimeter of the building. In this case, the “wall in the ground” will be able to perform, in addition to the protective part, the function of fencing the underground part of the building. The increased dimensions in terms of the underground part, larger in value than the dimensions of the upper structure, suggest the design of a “wall in the ground” as a supporting structure. The thickness of the "wall in the ground" is 0.8 m, depth - up to 25 m in areas bordering the existing surrounding buildings. Concreting is carried out by the method of VMP (vertically moving pipe). As a constructive event aimed at reducing the impact of new construction on the surrounding buildings [4] is the construction of a special geotechnical structure along the inner perimeter of the “wall in the ground”. This design is a soil reinforcing pile JET (Fig.

5). There are three types of jet-grouting technology: one-component JET-1, two-component JET-2 and three-component JET-3. The difference of these technologies lies in the organization of the process of destruction of the subsoil array and the installation of the ground-cement piles. The choice of jet cementing technology depends on the required strength of the ground cement, on the availability of the necessary equipment and other indicators established by the project.

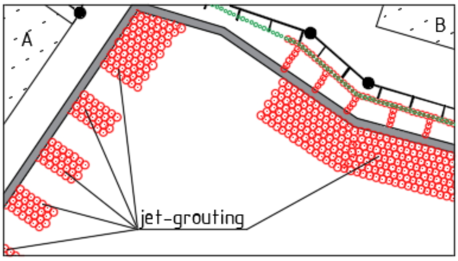

Fig. 5. Soil reinforcement by jet-grouting.

As an anti-landslide measure on the side of the structure C, as well as to combine the “wall in the ground” with the dividing wall, soil is strengthened by columns using the jet technology [9, 10] intermittently in 4 m steps. In addition, the ground mass is fixed between metal pipes [11, 12, 13]. The well device is produced by a hollow screw auger of the drilling rig to the design elevation. In the process of work, the soil is extracted from the well to the surface. After that, the auger is extracted, accompanying the process of extraction by forcing a cement-sand mortar into the zone of attachment. The solution is fed under high pressure through the screw hole. The injection solution supplied to the zone of fixation contributes to the hydraulic destruction of the soil mass. The sequence of soil consolidation is shown in the block diagram (Fig. 6).

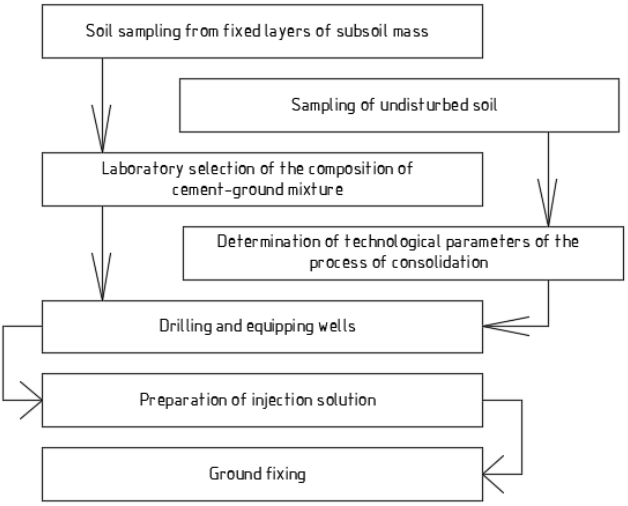

Fig. 6. The block diagram of the production works to consolidate foundation soils.

At the end of the activities described above (including the unexamined work of the preparatory period) the pile foundation of the building, which is projected. The construction of the pile foundation is made using bored piles [14] with a diameter of 800 mm and supporting struts of I-beam with nominal dimensions corresponding to the range [15]. A tower crane is mounted at the top of the base plate after the installation of the pile foundation.

3 Results

To ensure the stability of the enclosing structures against shear from horizontal loads, the fence is arranged according to the anchored pattern, for which it is planned to develop the soil from the excavation in a semi-closed way ("up-down") [16]. With this organizational and technological scheme, interfloor floor slabs of the underground part are used as spacer structures to prevent aclinic movements of the "wall in the ground" (Fig. 7). Thus, new construction minimizes the negative impact on nearby facilities.

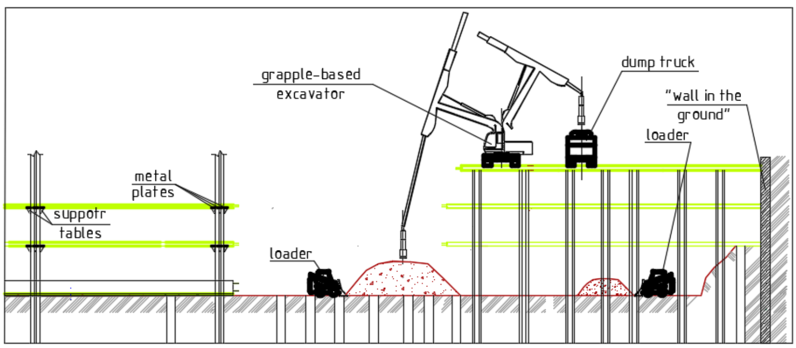

Fig. 7. Technological scheme of soil development from the pit by the "up-down" method.

To support the interfloor floor slabs within the height of the pit for the period of development of the pit, provision is made for temporary support struts of I-section with supporting tables made from metal plates. The supporting posts rest on the bored piles that make up the pile field (Fig. 8). Most of the racks coincides with the position of the main supporting elements of the frame. The internal structure of the new building takes place under the protection of previously erected ceilings, which provide for the installation of a technological opening for excavation (Fig. 9).

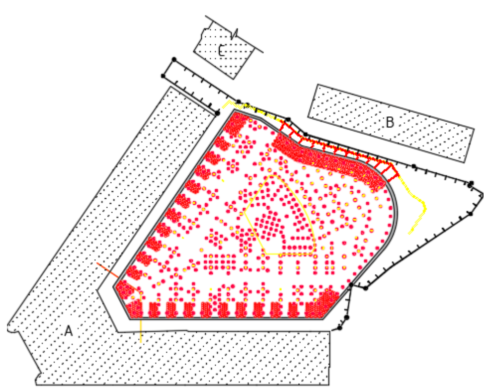

Fig. 8. Pile field and the location of the temporary support racks.

After the erection of the bearing and enclosing structures of the underground part of the building, the sinuses of the pit are filled up. Thereafter, constructions of the above-ground part of the building are arranged. There are monolithically executed walls of the stair-elevator units (rigidity cores), as well as internal and external columns. Overlaps and coves are also monolithic, based on internal and external columns and monolithic reinforced concrete walls. Then installed passenger-and-freight lifts, dismantled tower crane. The roof is flat, insulated, operated and unexploited with organized drain.

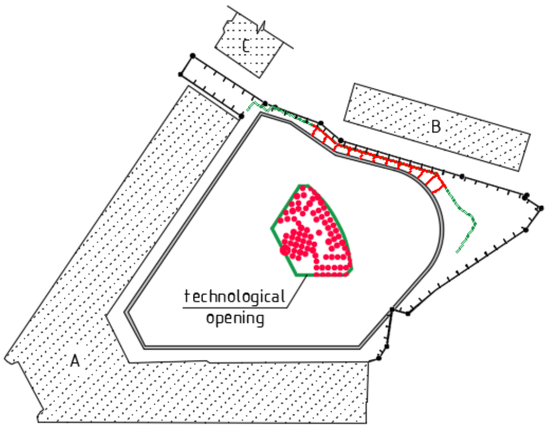

Fig. 9. The location of the technological opening.

During the entire construction period, as well as during subsequent operation, continuous geotechnical monitoring is conducted [17, 18, 19], which controls the following parameters: precipitation, roll, stresses in structures, crack opening width, WL (water level), horizontal displacements (Fig. 10). Taking into account the proposed organizational and technological solutions, the following changes in geotechnical parameters are predicted: the absence of horizontal displacements and the formation of new and the development of old cracks; an increase in stresses in structures as a result of equipment installation, an increase in groundwater table after the end of drainage measures, natural uniform precipitation occurs.

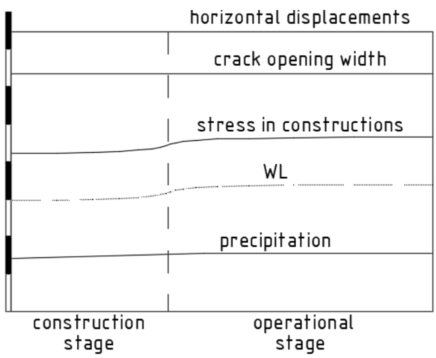

Fig. 10. The prediction of the changes in geotechnical parameters.

4 Conclusions

The given organizational and technological solutions contribute to the preservation of the integrity of existing structures. These decisions are a combination of the following measures: anti-landslide measures; strengthening of the soil mass of bases and foundations of closely located buildings and structures; excavation in the pit. The proposed solutions contribute to the neutralization of the complex effects of new construction, including the parameters identified in the process of work.

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