Foundation reconstruction technology

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Abstract. The building reconstruction process has a goal of increasing and improving of functional, constructional and aesthetic properties of a facility in the process of exploitation [1]. The creation of necessary environment, which characteristics and comfort level are defined by scientific and industrial progress, is always the main purpose of a dwelling. As construction sites and actual buildings grow denser and stead’s average prices become massive, the problem of useful spaces extension by means of extending a number of storeys (also underground ones). All that leads to an obligatoriness of the load bearing capacity recalculation for soil basis and building structures.

The authors give a description of completed work on increasing the area of an already existing low-story building by reconstruction of its basement and foundation and constructing the multifunctional underground complex.

The building is a 4-level 2-story cottage with an extension and the following constructions (Figures 1 and 2). The foundation is strip type with large blocks (500mm) resting on foundation slabs made of reinforced concrete slabs (10000*6000*150mm). Basement height is 2,2m. Basement floor consists of reinforced concrete slabs, (1200*6000*150mm). Brick walls, outer walls depth is 510 mm, inner walls depth is 380 mm. Wall reinforcement is absent. Prefabricated reinforced slabs (1200 and 1500*6000 mm) are used for overlapping, no anchoring with walls and between each other used. Ramped framed roof has been chosen.
The completion of the tasks was divided in 2 stages:

Foundation reconstruction with embedment of 2.4 m for height increase of all basement rooms;

Construction of a 2-story underground complex adjoining with the foundation of cottage’s main building.

Incorrect calculations of soil basis' load bearing capacity is the most common reason for erroneous decisions in reconstruction. That is the reason why geological researches are necessary for reconstruction exactly as they are for designing a new project [2]. Due to that fact the required researches of soil foundation’s physical properties at the facility were made to the depth of 14.5m.

According to the results and complicated conditions of construction, the decision was made to use slab foundation in appliance with DBC (Russian) 32-77. Structural diagram of the building and strength-and-rigidity characteristics of its elements define the level of responsiveness to soil deformations. The rigid structural diagram of the foundation used perceives stresses caused by deformations and transmits them to the building itself, which levels off soil basis’ drafts rearranging the pressure under the foundation. The structure is not affected by deformations [3].

The building being reconstructed with its brick walls and RC- slabs is classified as concerning rigid. Such buildings deforms with its foundation affecting the draft amount and leveling it off [4]. Due to that fact the decision made is the most rational.

Foundation reconstruction began with its breakdown by length. For this a research of physical properties of priming was done taking as deep as 7.5 m. The research showed that at this stage the working layer of the priming would be sandy loam with density of 2.05 g/sm3. Based on this research an optimal stage was chosen – 0.8-1.2 m2 (0.8-1.2*1.0 m).Further length increase (>1.2 m) led to wall subsidence and was unacceptable. After developing a plan a sequence for digging pits under existing foundations – every 3 stages.

The technological process of foundation arrangement was completed at each stage (figure 1) in the following sequence, allowing the beginning of the next step only after achieving concrete solidity level of the previous level. The work was completed in the following order:

- pit digging of set size under existing foundation;
- strengthening of the dug pit. Three vertical walls, excluding outer front one, were fixed by formwork made of waterproof plywood. Then the foundation priming was strengthened by ramming it with granitic crushed stone with a fraction of 20-40 mm at a depth of no more than 100 mm.
- Reinforcement and concreting of the foundation slab. Rebar with length of 30 diameters was hammered in the priming though the holes in formwork in order to have a connection with neighboring rebar frames. Rebar went out under inner walls on 4 sides and under outer walls on 3
sides. After knitting the main frame of the foundation slab the fourth side of the formwork was placed, and its volume was filled with concrete Mk. V25 with simultaneous vibrating. After achieving 75% of the durability waterproofing was put on above the foundation slab.

Foundation wall reinforcement. Formwork and foundation wall frame were mounted on waterproofing. The frame was tied with foundation slab anchoring. After mounting the formwork, the funnel with an excess of 0.8m above the horizontal joint was put on the top for delivering the expanding concrete. It allowed to decrease the concrete draught and avoid any gaps in horizontal and vertical joints in construction.

![Figure 3. The design of the Foundation](image)

For the basement floor the work on filling the reinforced concrete slabs (figure 4). The filling was done consequently room by room: the priming was taken off up to the bottom of foundation and then was condensed. Stripped of priming, parts of the foundation slab were tied with the slab frame. The concrete with vibration was put. Then the cycle was repeated on the next stage (next room).

![Figure 4. The device reinforced concrete slab basement floor](image)
The second stage of low-story building reconstruction was about constructing an underground complex. Following technical problems were solved:

Big depth of the foundation and communication – from 8.5m to 14.5m for construction and installation.

Direct contact of the constructions and building with already existing ones, forcing to hang out the foundation slab for 1.5m with height drop of 5m under it.

Across the foundation perimeter of the building complex the deep drainage system was planned along with height drop of 1m as well as communication and drainage wells on local sites dictated the height drop of 6 m.

Completion of this stage was also divided in two stages. The first stage (figure 5) had excavation and formwork. The pit had next size: 45*10 m and depth of 4.6 m on the plan and later section of the pit with size of 22*10 m was deepened b 3.9 m to -9.5m. Total volume of the priming was 3500 m3. The priming excavation was done manually allowing for a simultaneous formwork.

Vertical wall bracing was done with trimming board with cross-section of 150*50 mm, while vertical walls and spacers were done with channels and angles, which were put in place of wood spacers after losing its load-bearing capability. Spacer frames were mounted every 1.5m following the excavation with a step of 4 m.

Figure 5. The first stage of the installation of underground complex of buildings

The second stage (figure 6) had excavation in a trench 1.4 m wide, 4.9 m deep (with drainage) and 80 m long. The technology of the process includes:

- trench digging with formwork assembly
- installation of bored reinforced concrete piles 300 in diameter and 2-6 m deep (260 items)
- construction of monolithic reinforced concrete walls of lower floors on elevation level from -8.5 m to -9.2 m.

- assembly of steel beams on built reinforced concrete walls for the installation of monolithic reinforced concrete overlap on elevation level -4.2m

The main problems were caused by groundwater. Using protection technology from groundwater was not profitable so the drainage system was installed. Drainage wells were assembled and the excavation in trenches started from them while keeping the bias towards the wells. The steel sheets were hammered in by both sides of the trench. These sheets were pinned to the priming by the formwork preventing the pulp from getting in. Dismantle of the steel sheets and formwork was done in reverse order along as sinuses were backfilled.
The setup of the piles under the monolithic reinforced concrete walls was due to several factors, among which were the priming diversity and close position of the drainage system. The piles were bored down to hard clay and below the bottom of drainage allowing for a reliable resting of the walls.

The steel beams were fixated with monolithic reinforced concrete walls by anchoring. So, the beam system could stand the load of the side pressure from the priming at the depth of 4.2 m even without the reinforced concrete slabs.

The last step of the second stage was the assembly of the reinforced concrete walls of the -1 floor. Special conditions were not present. After achieving the concrete solidity, the building of the underground complex entered its final stage.

![Diagram of second stage installation of underground complex of buildings](image)

**Summary**

The foundation reconstruction was done without touching the above floors of the building. During the foundation reconstruction it is necessary:

- accurately define and follow the measures of the stages in order to prevent any uneven building draught
- assess the stability and durability of the retaining wall during the pit digging
- conduct an in-depth assessment of the engineering and geological conditions
- conduct a full assessment of the cost of any future work and possible unexpected expenses
- in order to prevent a rise in price of the construction and conduct a full monitoring of quality of any unfinished work

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