Industrial Risks and Technological Safety

Geotechnological Monitoring as a Method of Ensuring the Safety of Driving of Metro Tunnels Under Restrained Urban Conditions

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ABSTRACT

Moscow is the most dynamically developing metropolis in the Russian Federation. It is a city with almost a thousand-year history. Here, on an area of 2.5 thousand km^2, about 12.5 million people live. In 2012, the Government of Moscow adopted the Resolution "On the Approval of the List of Perspective Construction Facilities of the Moscow Metro", according to which by the end of 2027, 329 km of new lines and 151 stations are to be built. This will reduce the load on the existing metro network, as well as provide "step-by-step access" to stations for 93% of the population of Moscow. In total, from 2011 to 2019, 50 new metro stations, about 82 km of new lines and 10 electric depots were built in Moscow. In total, construction work is underway at more than 300 construction sites in the city, involving 23 TBMs with a diameter of 6 m and 4 TBMs with a diameter of 10 m. On average, in the zone of influence of the construction of 1 km of metro main line tunnels, there are about 15 - 17 existing buildings and structures.

Analysis of controlled [5 ... 10] parameters that assess the impact of tunneling on the safety of existing buildings and structures located in the zone of influence of construction can be systematized as follows: 1) Parameters characterizing the stress-strain state of the soil mass and engineering structures. 2) The restrictions imposed on the working conditions or on the placement of newly constructed structures in relation to existing underground structures. 3) Technological parameters, mainly related to the dynamic effects transmitted through the foundation soils to the structures of buildings and underground facilities, as well as the "technological deformations" of existing buildings and structures as a result of pile driving and sheet piling, as well as the construction of "slurry wall" The latter can be associated not only with dynamic effects in the process of pile driving but also, for example, with the movement of the walls of the trench "slurry wall" when the bentonite clay solution composition is improperly selected.

The current regulatory documents of the Russian Federation, as the main quantitative parameters that determine the degree of safety of the impact of new construction on existing buildings, use the maximum permissible deformations - the maximum settlement and the relative difference of the settlement. In addition, it is possible to measure stresses in structures and soil mass, vibration parameters (kinematic parameters of vibrations, vibration displacements, vibration velocities and acceleration), however, these parameters are either not standardized or are established by sanitary standards, i.e. they do not have a direct quantitative relationship with the safety of buildings and structures. At the same time, the authors [2] indicate that the technological component of the settlement of an existing building in the process of new construction can reach 40% of the total settlement, and in [1] it is shown that with the installation of shut-off screens of various designs, the portion of technological settlement in the process of their manufacture varies from 30 to 90% of the total settlement of the building, including settlement from the underground excavation or excavation of the pit. The same opinion is shared by the author [3], who showed that in the engineering and geological conditions of St. Petersburg this ratio can reach 80%.

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Thus, when using the cut-and-cover construction method, on average technological sludge delivers about 60% of the total measured value. When using a trenchless construction method this value exceeds 90%. To manage the technological impacts on the deformations of existing buildings and structures, it is proposed to conduct geotechnological monitoring as part of the scientific and technical support for construction, aimed at predicting and controlling technological deformations during the construction process, developing and implementing compensating technological measures that ensure the safety and safe operation of existing buildings and structures instead of strengthening their foundation soils, foundations and engineering structures. Based on the experience in the scientific and technical support of underground construction in the city of Moscow, a set of works on geotechnological monitoring is proposed:

1. Analysis of the adopted technological decisions concerning construction and the identification of technological operations that can lead to deformations of buildings and structures durnig the constructino process. At the same time, it is necessary to exclude from the design solutions that use technologies that do not correspond to the categories of "high technologies" of underground construction of classes 2 and 3.
2. Forecast of technological deformations.
3. Analysis of geotechnological risks, which will identify the most dangerous technological operations during construction and minimize their impact on the safety of operation of existing buildings.
4. Development of technological regulations.
5. Monitoring:
    - of technological deformations during the construction process using modern high- precision automated monitoring systems.
    - of technical condition of buildings and structures.
    - geophysical monitoring of the state of the soil massif.
    - of parameters of vibration effects during the construction process.
6. Control of technological parameters of the production of geotechnical works and the quality of construction.
7. Operational adjustment of the parameters of the technology of geotechnical works. The application of this approach has already allowed:

1. To ensure the safety of buildings and structures along the Nekrasovskaya and Bolshaya Koltsevaya metro line.
2. To replace traditional solutions of strengthening of foundation soils, foundations and engineering structures with compensating technological measures during sinking.
3. To ensure a reduction in construction time and budget savings on these metro lines under construction of about 7.5 billion rubles.

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