Monitoring of deformation processes during scientific and technical support of construction

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Abstract. With the scientific and technical support of construction, reconstruction of buildings, structures and unique objects, the issue of assessing the development of deformation processes in newly erected elements, in buildings of surrounding buildings, underground utilities falling into the zone of influence of construction and transport infrastructure facilities is very acute. This task is now being successfully solved by combined methods using traditional geodetic methods and laser scanning using high-precision total stations with the ability to scan.

With the scientific and technical support of construction, reconstruction of buildings, structures and unique objects, the issue of assessing the development of deformation processes in newly erected elements, in the buildings of surrounding buildings, underground utilities that fall into the zone of influence of construction and transport infrastructure objects is very acute. This task is currently successfully solved by combined methods using traditional geodetic methods and laser scanning using high-precision total stations with the ability to scan safety of surrounding buildings and structures [1-3]. The scientific and technical support of construction is of particular relevance in the renovation of metropolitan areas, when projects are implemented in areas surrounded by dense urban development on the site of previously existing facilities that do not meet modern requirements for the rational use of urban areas [4, 5].
Such territories include industrial zones, areas with low-rise buildings, industrial and civil facilities that have an unsatisfactory technical condition or do not meet modern requirements for objects of this class. The complexity of the implementation of such projects lies in their uniqueness, the complexity of the construction conditions by the presence of many complicating factors and the need to take into account the impact of construction on the surrounding buildings and communications that fall within the zone of influence of construction. Ensuring the construction of the pile foundation and fencing of the pits of the projected building, which can be of various types both according to the methods of construction of the fences themselves, and according to the method of their fastening during the development of the pit, requires special approaches and qualifications for scientific and technical support of construction.

During the construction of the underground part of the construction objects, the pit fences around the perimeter perceive horizontal loads from the soil-rock massif. During the

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period of operation, the fences also perceive vertical loads from columns and ceilings resting on the fence and loads from stored building materials and small-sized equipment during the construction period, that is, in these areas, the fences are permanent load-bearing structures of the building.

During the implementation of scientific and technical support of construction at the first stage, geotechnical calculations of the impact of the construction object on the surrounding buildings are performed by the finite element method, the zone of influence is determined and the forecast of the increment of deformations of structures of existing buildings and underground utilities located in the zone of influence is carried out [6-8].

According to the construction object, the available technical documentation is being studied, namely the materials of engineering surveys and project documentation. The analysis of completeness and sufficiency of the conducted research and elaboration of the project is carried out. Based on the results of the analysis, a conclusion is made about the sufficiency of information, or the need for additional research.

If additional surveys are needed, a survey program is developed and sent for approval to the customer for scientific and technical support. If the initial data are sufficient, on the basis of engineering and geological surveys, the calculated parameters of the soil-rock massif are selected and a finite element geomechanical model is constructed, including the projected object and the surrounding building.

According to the stages of construction, the calculation of changes in the stress-strain state in the model is carried out in the volumetric formulation, taking into account the interaction with the projected construction object in the software package, for example, PLAXIS 3D. Elastic and elastic-plastic mathematical models of the hardening soil are used to model the mechanical behavior of the structures of the pit fence, structures of existing buildings, reinforcement piles, structures of the construction object and engineering-geological elements when their stress-strain state changes (Hardening soil model).

Figure 1 shows an example of calculating changes in the stress-strain state for a multifunctional complex under construction.

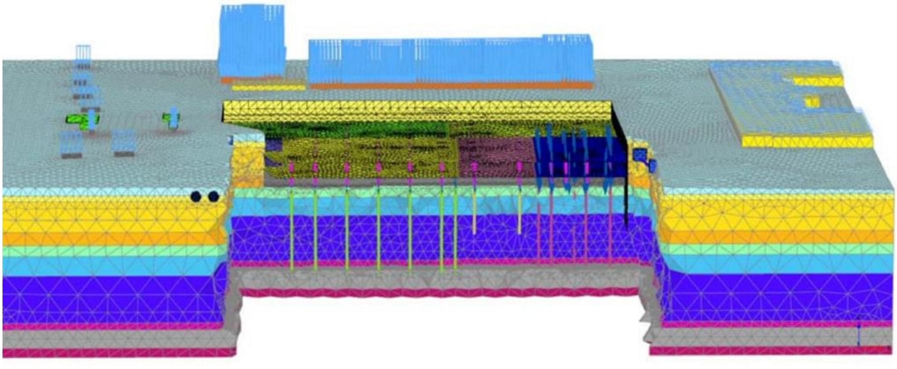

Fig. 1. Calculation of changes in the stress-strain state in the model in the volumetric formulation, taking into account the interaction with the projected construction object.

The elastic model is used to simulate the operation of structural materials (concrete, rubble/brickwork, metal) of the excavation enclosure elements and structures of existing buildings.

A qualitative and quantitative analysis of the calculations of displacements, stresses and deformations at various stages of construction is carried out, the results of which are reflected in the conclusion and the construction of isolines of the stress and displacement components in the soil-rock massif.

At the second stage, geotechnical and technical monitoring of construction is carried out. During geotechnical monitoring, instrumental observations are made of the vertical movements and roll of the foundations of a newly erected or reconstructed structure, horizontal and vertical movements of the soil and rock mass surrounding the structure and horizontal movements of the enclosing structures of pits, as well as additional vertical and horizontal movements, additional roll of structures of buildings and structures surrounding buildings.

Technical monitoring is carried out by visual and instrumental quality control of erected structures at the stage of construction and operation of the construction object [9-12].

The main methods of geodetic measurements of vertical and horizontal displacements are traditionally geometric leveling using high-precision digital levelers with invar rails, which ensures the accuracy of the vertical displacement vector of 0.3-0.4 mm, trigonometric leveling using high-precision electronic total stations, the projection method using high-precision electronic total stations and linear-angular constructions using high-precision electronic total stations, which provides the accuracy of the information received, up to 1 mm in plan and height.

Currently, there is a need to carry out these works on unique capital construction projects with a height of more than 100 meters, spans of more than 100 meters, the presence of a console of more than 20 meters or the deepening of the fully or partially underground part of more than 15 meters, which is complicated by dense urban development, the movement of people, urban transport, very limited cramped territory of construction sites, storage and the movement of construction materials and equipment, and often the inability to install a monitoring device in the same place.

A significant problem of monitoring is to ensure the safety of the established deformation marks on the monitoring objects and in the soil-rock massif - when the marks are destroyed / damaged, the analysis of information on the development of deformation processes is complicated.

To overcome these problems and improve the accuracy, productivity and information content of the information received on the development of deformation processes during the construction process, scientists from the Moscow State University of Civil Engineering successfully use combined monitoring technologies, namely, along with traditional geodetic measurements, laser scanning is used.

Traditional laser scanners for monitoring purposes can be used very limitedly due to the insufficient accuracy of the results obtained, but in the process of using a robotic total station for these purposes with the possibility of laser scanning in real operating conditions at construction sites, an accuracy of 1 mm is achievable, which satisfies the requirements for monitoring.

Fig. 2. Laser scanning of building structures scanning total station Leica MS60

Fig. 3. The result of scanning the building structures scanning total station Leica MS60

The indisputable advantage of using a robotic total station with the ability to scan is that it can be used to perform a set of traditional high-precision measurements at individual points and reference points, as well as perform laser scanning [13-15].

Currently, the Moscow State University of Civil Engineering, together with the Russian State Geological Prospecting University named after Sergo Ordzhonikidze, is studying the possibility of using the Leica GS-16 GNSS receiver in the base station mode when monitoring using a Leica MS60 scanning total station. This integrated solution allows you to significantly increase the flexibility of the solution in the cramped conditions of the construction site and makes it possible to control the stability of the position of the scanning total station during measurements at the facility, when the duration of measurements can be calculated in hours for very large and complex objects.

An acute problem in the analysis of the results of observations of deformations during scientific and technical support of construction is the assessment of the accuracy of the data obtained, since on the same scan there are areas in which the errors in obtaining coordinates have different accuracy, which may eventually affect the assessment of the development of values and the rate of deformation processes.

 https://doi.org/10.1051/e3sconf/202341002045

Based on the models obtained as a result of laser scanning, it is also possible to solve problems related to assessing the quality of construction and obtaining metric models of a structure under construction at a given point in time.

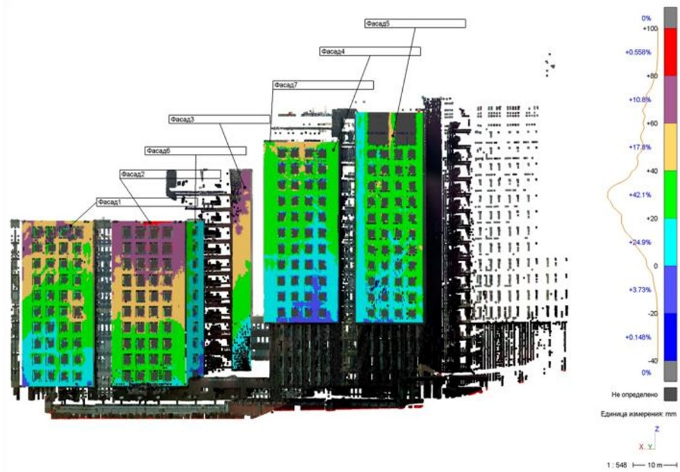

Fig. 4. Determination of the initial rolls of the building based on the results of laser scanning

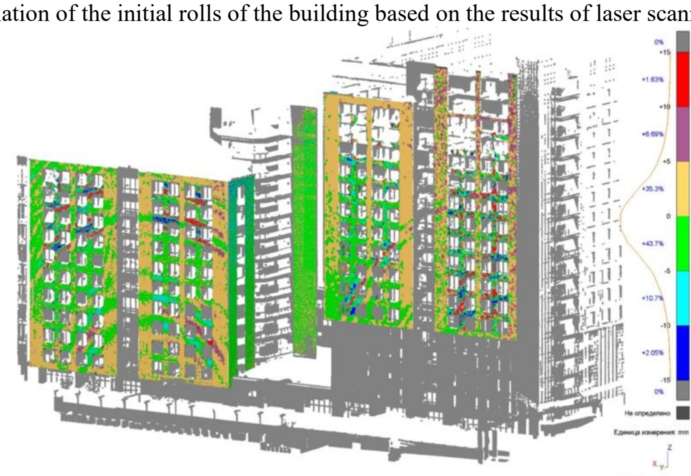

Fig. 5. Repeated laser scanning

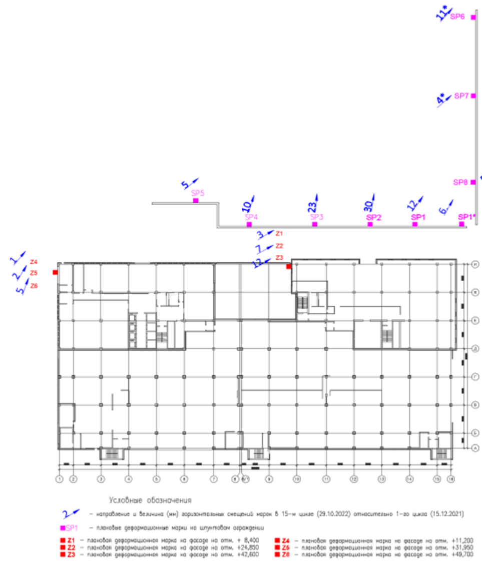

Fig. 6. Definition of roll increments

Based on the results of high-precision laser scanning using high-precision scanning total stations, it is possible to solve the problem of geodetic control during construction and installation works, which are shown in Figure 7.

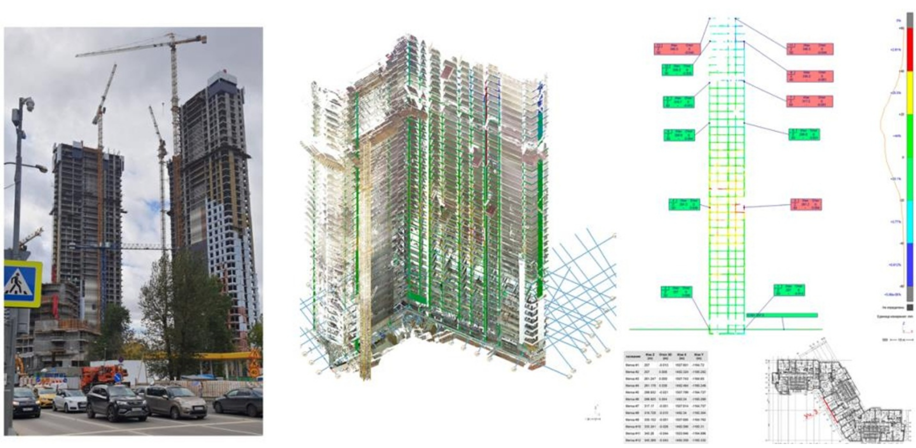

Fig. 7. Geodetic control of the construction of a 170 m high building using scanning total stations.

Thus, in the process of carrying out geodetic work on the scientific and technical support of construction, the effectiveness of using high-precision electronic tacheometers with the possibility of scanning to monitor the development of deformation processes in the structures of structures under construction, the surrounding buildings and the enclosing soil and rock massif has been proven in practice, which allows achieving the required accuracy and efficiency of obtaining information.

This work was financially supported by the Ministry of Science and Higher Education of Russian Federation (grant # 075-15-2021-686). Tests were carried out using research equipment of The Head Regional Shared Research Facilities of the Moscow State University of Civil Engineering

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