Prevention of Man-made Emergencies During Tunnel and Subway Construction and Operation

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ABSTRACT

The construction of the subsurface facilities, such as the subways, tunnels of various purpose involves the change in the stress state of the containing body, which influences strongly upon "lining - containing body" system, tunneling work safety and operation reliability when combined with the natural hazards, such as the seismic activity, landslide processes, tectonic zones, etc. The elaboration of the actions directed at the safety improvement during construction and the elimination of the environmental impact, prevention of the man-made emergencies shall be a part of the design documentation for the tunnel and subway construction in accordance with the Russian Federation legal framework, as follows: Urban Planning Code, Federal Law Technical Regulations on Safety of Buildings and Structures dated 30.12.2009 № 384, Regulation № 87 dated February 16, 2008 On Composition of Design Documentation Sections and Requirements to Their Contents. The elaboration of such actions can be included into the scope of the geotechnical monitoring, which unfortunately consists currently of only geodetic monitoring and hydrostatic leveling for the buildings that falls within the construction area of influence during the construction of Moscow Metro. These works are necessary but they are directed at the emergency recording rather than the emergency prevention.

The relevance of the elaboration of actions directed at the emergency prevention is supported by a great number of the contingencies during the construction of Moscow Metro showing the lack of information, which would allow to take timely actions for the situation stabilization, to avoid the subsequent vast expenses for the remedial actions, to reserve the construction machinery and to observe the construction scheduled time. The example of such works is, for instance, the slurry wall construction. In spite of the maturity of the technology for its construction, a great number of its discontinuities resulting in the emergencies are recorded. At that, the consequences of the emergencies affect not only a construction site, but they have sometimes a strong adverse effect upon the structures and utilities outside the construction site.

The important task of the geotechnical monitoring is a control of the strain-stress state (SSS) of the building structures constructed, the results of which are important not only during construction for the elaboration of the recommendations for decrease of the environmental impact, but during the tunnel and subway operation in order to control the changes in the structure SSS due to the operational loads. The illustrative example is the vibration and dynamic loads in the subsurface facilities due to the traffic flow of the railway or vehicular transport. The automatic geotechnical monitoring system of nine transport tunnels (3 vehicular tunnels and 6 railway tunnels) at Adler – Alpika-Service section in the scope of APCS (automatic process control system) allowed to obtain the confirmation of the actual strain-stress state distribution between the containing body, temporary support and permanent lining during operation of the subsurface facility, which has existed before only as the hypothesis.

The regulatory technical documentation in Russia indicates that the choice of the structure, parameters and support calculation of the underground working shall be performed as the differentiated one for the rock sections with the same properties based on the rock stability assessment, values of their displacements,

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support loads, considering the possibility of the comprehensive mechanization of the support manufacture and construction processes, assurance of the work reliability and safety for the whole service time of the underground working. Meanwhile, there is no information on how the combined work of the temporary support and permanent lining shall be considered in the calculations.

The results obtained using the above automatic geotechnical monitoring system prove that the temporary open support structures, even with their arrangement in the semi-rock soils, gradually lose the resistance with the containing body. At that, all load from the rock pressure begins to transfer to the permanent lining. It takes place because during the traffic flow the vibration and dynamic loads cause gradually the loss of the body strength properties under the support feet, and the vertical displacement in some millimeters results in the gradual load transfer to the permanent structure.

Such process, depending on the mechanical-and-physical properties of the containing body, can last for years and, perhaps, for decades. So, during the operation of the railway tunnel located in the limestone and with the laying depth equaling to 2 – 4 of its diameter from the surface, the permanent lining SSS begins to stabilize at the end of 2019; that is in 6 years after the commencement of operation. At that, the SSS stabilization has been recorded in the first place after the completion of the tunnel construction.

In the same time, the long-term studies (15 years of operation) of the lining SSS in the rock soils within the conditions of Severomuysky Tunnel do not show such stress state redistribution between the open temporary support and permanent lining. The availability of the up-to-date information obtained using the geophysical, geomechanics and geodetic research methods during the construction and operation of the subsurface facilities allows for not only emergency prevention but for the elaboration of the recommendations for decrease of the environmental impact. The operating experience of the automatic geotechnical monitoring system of "Olympic" tunnels allows for the reasonable approach to the issue of revision of the departmental regulations for the tunnel and subway operating companies regarding the mandatory use of the automatic monitoring systems for the forecast of the technical condition of the subsurface facilities.

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