Technogenic Safety of the Russian Railway Transport Infrastructure (Railway Tunnels)

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ABSTRACT

The increasing complexity of technosphere objects and increasing the operational parameters of their functioning steadily entail an increase in natural, technogenic, technological and industrial risks. This is becoming one of the important topics of integrated security. The generalization of Russian and foreign experience in solving complex issues of life safety of the state, society and human is one of the main goals of the unique multi-volume publication "Security of Russia". The issue was launched in 1997 by decision of the Presidential Administration and the Security Council of the Russian Federation [1]. In 2019, the publishing house "Znanie" began the preparation of the next volume of the series entitled "Security of Russia. Railway transport. Technogenic safety". The work on the section "Technogenic safety of the railway transport infrastructure" is attended by the staff of JSC "NIPII Lenmetrogiprotrans" institute. The main task in the data preparation is to consider ways and methods, systems and means to increase technological safety and reduce risks at all stages of the railway tunnels life cycle.

Railway tunnels - capital structures designed for a long service life. In accordance with the requirements of the current regulatory documentation, the technical decisions, as well as the applied structures and materials, must ensure the tunnel service life of at least 100 years. The overhaul periods of permanent structures should be at least 50 years. During this period, they must meet the requirements of operational reliability, durability, maintainability of the structure as a whole and in its components. Also, the ability to perform specified functions, while maintaining their operational performance within certain limits, at specified operating conditions in the periods of operation, maintenance and repair [2]. Continuity and safety of railway traffic on the most difficult sections of highways largely depend on the working condition of the tunnels. Therefore, it becomes especially important to study the conditions of reliability and durability of their exploitation.

The solution to the problems of improving the operational qualities of existing railway tunnels is complicated by the presence of a wide variety of tunnels structures types and lining of tunnels those which were built at different times. At the beginning of the 21st century, there were 160 tunnels on the railways of the Russian Federation with a total length of about 110 km. According to a technical survey summarized in 2003 in the "Atlas of Russian Railway Tunnels", many structures had various violations, the main ones being water cut of varying degrees and structural deformation. During the inspection, defects were noted in the form of a significant decrease in the lining strength, cracks and outfalls in obsolete masonry, including through ones with deformations of the earth's surface above the tunnels. Currently, the number of railway tunnels that do not meet modern requirements has been reduced due to the large amount of work on overhaul and reconstruction of structures built in the late 19th - early 20th centuries, as well as the construction of new tunnels parallel to the old ones. Examples are: the Khingan tunnels reconstruction on the Far Eastern Railway (2009–2013), tunnels in the North Caucasus (1998–2014), the Tomusinsky Tunnel on the West Siberian Railway (2018), and a number of tunnels on the Krasnoyarsk Railway (2006–2018),

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as well as the construction of new railway tunnels for the Olympic Games in Sochi and others. This trend continues - new tunnels are being designed in the Caucasus and Siberia. Far East, the modernization of the Baikal-Amur Railway (BAM) continues with the construction of new tunnels and reconstruction of existing ones.

In tunnels under construction, reconstruction and those which are in use, the overwhelming majority of accidents are due to insufficient consideration or incorrect assessment of the numerous determining factors that can be combined into two large groups: natural and technogenic (man-made) factors. The reduction of natural and technogenic risks and ensuring the safety of railway tunnels is carried out at four levels.

The first level is design decisions. The second is the development of an observation system as a part of geotechnical monitoring (GTM) during construction and operation period. GTM system controls the state of the tunnel and environmental parameters, which together form a natural-technogenic system. The third level is the development of a system for responding to past or forecasted dangerous natural processes and phenomena in order to prevent or reduce negative consequences. Actualization and control of the risk level by GTM systems, improvement of response schemes. The fourth level is the development of new generations of technical and technological safety solutions for underground construction in general and for each specific tunnel project separately.

An example of the successful implementation of geotechnical monitoring together with the automated process control system (APCS) is the railway and road tunnels on the Adler - Krasnaya Polyana section, built between 2008 and 2013 in preparing the infrastructure for the XXII Olympic Winter Games Sochi, Russia [3]. This project is the most ambitious work in the Russian Federation to implement an automated geomonitoring system in transport tunnels under construction.

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