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Innovative technology for repair of culverts in conditions of constant intense water flow

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Abstract

The proposed innovative technology "Saturn" is suitable for the repair of all types of culverts on the Russian railways, especially for the repair and reconstruction of the pipes under the conditions of permanent intense watercourse, with unusual (non-typical) design solutions, as well as for pipes located in remote sections where it is difficult to arrange construction sites.

The developed innovative repair technology has been successfully applied to the Oktyabrskaya Railway, or October Railway, since 2013 for repair and reconstruction of stone and concrete culverts of long-term operation and pipes of various outlines of openings ranging in size from 1.5 m to 4.2 m, including in the conditions of permanent watercourse, while a pipe is filled by flow up to 1.6 m of its section.

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Keywords: innovative technology, repair, culverts, intense water flow.

1. Introduction

The intensive growth of cargo turnover at the railways has entailed the increase of loads applied to the elements of the railway track. Due to the trend of increasing axle loads up to 30 tons and train speeds up to 300 km/h and

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more it is necessary to enhance reliability of culverts, which operation period exceeds 100 years. During the long-term operation most culverts have suffered considerable physical wear and they have lost the accepted design and exploitation parameters. Finally, it leads to the decrease of train loads, limitation of allowable speeds and reduction of a transit capacity of the railways. The annual increment of defectiveness of culverts in 2005-2015 increased almost twofold. In order to provide reliable operation of culverts at the modern level there is a need to increase implementation of innovative technologies for their repair and reinforcement. The paper informs about the solution of these relevant problems.

2. The subject matter and experimental-theoretical substantiation of the proposed technology of culvert repair

2.1. The subject matter of the proposed technology.

The increase of loads applied to the railway bed elements during the intensive growth of cargo traffic at railways, stated in the Strategy for Development of Railway Transport of the Russian Federation until 2030, requires providing safety and reliability of railway engineering facilities. Reliability and safety of culvert facilities, in particular, pipes, is a very relevant issue for providing working conditions of the railway bed elements. It is linked to the current trend of the climate change and, as a consequence, its active seasonal floods and precipitation in spring and summer periods during the recent decades, when daily and monthly rates of precipitation exceed the average values several times, that causes flooding and underflooding of roads as well as numerous inhabited and uninhabited areas.

The long-term exploitation of railway culverts, many of them have been operating for 100 years and more, despite regular repair, has led to a considerable physical wear of their structures and the loss of the accepted exploitation design parameters, limitation of a maximum traffic speed and reduction of the capacity of railways.

The data of The Main Directions of Providing Reliability of Exploitation of Railway Engineering Structures at the Contemporary Technical and Technological Level (Resolution # 275 of 14.08.2013) [1] state that an annual increment of defectiveness of culverts is the most intensive compared to other artificial structures and other elements of the railway track, in recent five years it has increased almost twofold. It is a deterrent for increasing traffic and freight capacities at almost all directions of the network of railways. The resolution also notes that in order to provide reliable exploitation of structures at the contemporary level there is a need to expand introduction of innovative technologies ensuring safety and reliability of the railway track and railway transportation.

- Today, as a rule, it is impossible to meet these requirements and to provide safety and reliability of culverts commeasurable with other elements of railway engineering facilities at increasing impacts and loads due to a number of reasons [2]:
- Scattering of pipes along a route and difficulty of access due to the lack of roads located near a route [3];
- A prevailing variety of types of pipes according to structural solutions and materials as well as the absence of typical unified technical solutions on their repair [4];
- A lack of reliable industrial technologies allowing repair of pipes during their exploitation;
- The reduction of an average annual amount of financing for repair and reconstruction of artificial structures prevents repairing of pipes to such an extent which is necessary to ensure their exploitation reliability at present and in the long run [5].

The theoretical researches of the Russian [3, 9] and foreign [5, 7] authors have shown that increasing static and dynamic loads applied by trains cause defects in long-operating culverts, which violate integrity of structures of an RC or a stone culvert. During the long-term impact a structure operates not as an internal body but as separate elements. These exploitation defects increase and can result in failures. The calculations of the foreign scholars [6, 13] show that bearing capacity of defective structures can decrease 1.5-2.5 times.

Given the increasing necessity to find an effective way of solving the abovementioned problem and during the study of the issue for many years including its development in the network of railways both before 1990s in the USSR and in the railways of the Russian Federation, the experts of St. Petersburg State Transport University together with the Institute “Lengiprotransput” and the Track Service of the Oktyabrskaya Railway worked out a