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ICE LAYERS IN TUNNELS

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by

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ICE LAYERS IN TUNNELS

The construction of tunnels in mountainous areas with complex hydrogeological conditions interferes with the natural hydrothermal regime and established conditions of the groundwater flow. In a number of cases the derivation of the groundwater from the opened water-bearing levels involves the use of drain troughs in the tunnels.

Such tunnels on the railroads of Siberia, the Far East and the Ural Region contain ice layers which are particularly dangerous, as the ice frequently covers the rail tracks interfering with train traffic.

All this requires continuous observation of the ice-forming process, chipping and removing the ice from the tunnel. These operations are very labor-consuming as they are performed manually in limited space and under artificial light.

The loading and removal of the ice from the tunnel by railroad flat-cars requires openings, and this complicates the maintenance of the tunnel.

In wintertime many teams of road workers have to be diverted from their current maintenance work.

In tunnels with damaged waterproofing or without it (the Far Eastern tunnels were built in 1910-1914), the groundwater seeping through the seams or cracks of the tunnel lining freezes and forms ice stalactites along the top and the walls and ice hummocks on the rail tracks. The ice freezing together with the tunnel lining and filling the cracks and seams may destroy the stonework.

In wintertime the position of the rail tracks may be changed by the ice-formation process, by chipping the ice as well as by the development of ice humps or hydrolaccolites.

The development of ice layers in tunnels is predetermined by the presence of subterranean water (the source of ice-layer formation) and the negative temperature (the cause of the icing process) whereby the water entering the tunnel freezes up.

In this connection, the measures used to eliminate the ice layers are designed to prevent the freezing of the water coming into the tunnel.

The first group includes all the measures - from the construction of gates in front of the tunnel entrance to the use of special boilers designed to maintain a warm temperature.

Many tunnels are currently equipped with boiler heating devices.

In a number of cases the ice can be removed from the rail tracks in the tunnels by jet-powered snow cleaners.

Attempts have been made to inject a cement solution behind the lining in order to prevent the groundwater from entering the tunnel.

Chemical methods of soil-fastening designed to produce water-resisting shields behind the tunnel lining have been developed in recent years and are still being developed in the Soviet Union and abroad; these methods are based on the use of high molecular synthetic compounds, such as methyl acrylamide [2].

Under the method developed in the U.S., clayey ground moistened to the yield point is hardened with calcium acrylate which is introduced into the ground (an equivalent of 8-10% of the ground weight) together with the following activators: ammonium persulfate, and sodium thiosulfate (1%). The desired ground-hardening effect is achieved in 6 to 8 hours. When dried the strength of the hardened ground amounts to 100 kG/cm^2 and more.

A method has been developed in the USSR of insulating stratal water with water-resistant shields produced by the use of carbamide and furfural resins, etc.

The use of carbamide resin is recommended for fastening clayey ground with a filtration coefficient of 3.10^{-4} to 5.10^{-3} m/sec containing about 3% clay particles and a pH water extract 7.5. The reagents are introduced into bore holes by injectors. Gelatination occurs in 15 to 20 hours.

High molecular resins can thus be used for fastening the ground behind the tunnel lining for waterproofing purposes and controlling the flow of groundwater along with the other known methods (chemical soil hardening, bituminization and cementing).

The selection of the method should be based on careful engineering and hydrogeological investigations of the rocks and technical and economic calculations.

Icing can be prevented as a rule by the introduction of a reliable waterproofing system or a heated drainage and damming derivation system.

Tunnels can be kept dry by drilling damming wells followed by channelling the subterranean water into a draining system [1].

The interception and derivation of the groundwater by ascension damming wells considerably reduces the filtration of water through the tunnel lining, and in a number of cases eliminates it altogether.

The wells are drilled from special chambers located behind the tunnel lining on the level of the lower drainage adits.

The 15 to 30 wells usually drilled from each chamber are arranged in fan-like formation in two layers: the first layer is for damming the water entering the track foundation; the second is to capture the water seeping through the tunnel lining above. It would be most rational to use the BA-100 drilling machine which has a capacity of 10 to 15 meters per work shift.

The direction, length and number of wells should be designed to intercept all of the water entering the tunnel.

The application of this method on the Transbaikal, Far Eastern and other railroads has produced good results:

ice layers no longer develop in the tunnels;

the destruction of the tunnel lining produced by repeated freezing has ceased;

the hummocks previously found in large numbers in the tunnels have disappeared.

The method of draining tunnels and eliminating the ice layers by drilling deep damming wells can be applied on a wide scale to tunnels located in nonfissured and slightly fissured rocks.

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13. ABSTRACT

Since the formation of ice layers in tunnels is due to a combination of subterranean water and cold temperature, the methods of draining such tunnels should be designed to prevent the seepage of water through the tunnel lining and to maintain an above-freezing temperature. It is therefore recommended that icing on railroad tracks in tunnels be prevented by ground fastening, the drilling of damming wells, the installation of derivation troughs as well as heating devices to maintain a warm temperature.

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