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Innovative engineering solutions for improving operational safety and efficiency of subways with two-way tunnels

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Abstract

The paper considers the problems of improving the operational safety of the two-way tunnel subway under weather conditions characteristic of Russian megapolises. A significant difference is indicated between annually mean, monthly mean and extreme outdoor air temperatures affecting thermodynamic parameters of the intra-subway atmosphere in Russia and foreign countries having subways. Comparative characteristics are given for the factors determining temperature regimes of the subway lines with single-way and two-way tunnels in case conventional ventilation schemes are used. The paper also describes alternative ventilation schemes involving constructive elements widely used for venting motor-road tunnels. Based on specific initial data, calculations have been performed whose results characterize temperature distribution in running single-way and two-way tunnels vented by using the ventilation scheme comprising vent ducts and air recirculation. The efficiency of the two-way tunnel ventilation scheme comprising a ventilation duct and air recirculation has been justified. Mathematical simulation of the dynamics of smoke propagation in case of a fire in tunnels and at stations has been accomplished. Efficiency of the emergency ventilation scheme comprising a vent duct in smoke protection of the fire evacuation passages for people and in smoke removal has been proved. The paper presents such station complex layout solutions that, contrary to historical prototypes, imply integrating the station ventilation and smoke removal systems into the general structure of the station space-planning solutions so that they are in close vicinity of all the designed passenger flows with retention of the comfortable space necessary for passengers.

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1. Introduction

The use of two-way subway running tunnels has become possible due to creation of large-diameter tunnel boring machines enabling tunneling at the 10 to 15 m depth in densely populated megapolis districts without damaging the ground surface and negatively affecting the condition of buildings and structures.

Analysis of the international practice in subway construction evidences that construction of two-way tunnels leads to cost reduction by approximately 20-30% with respect to conventional single-way tunnels and also to reduction of the work schedule.

Another positive aspect of subway lines with two-way tunnels is creation of more favorable (as compared with single-way tunnels) conditions for people evacuation from dangerous zones in emergencies because in this case their walking speed is higher and the maneuver space is larger.

The most widespread type of lines with two-way tunnels is shallow station complexes with a two-way railway in the station center and two platforms at the station periphery (Fig. 1).

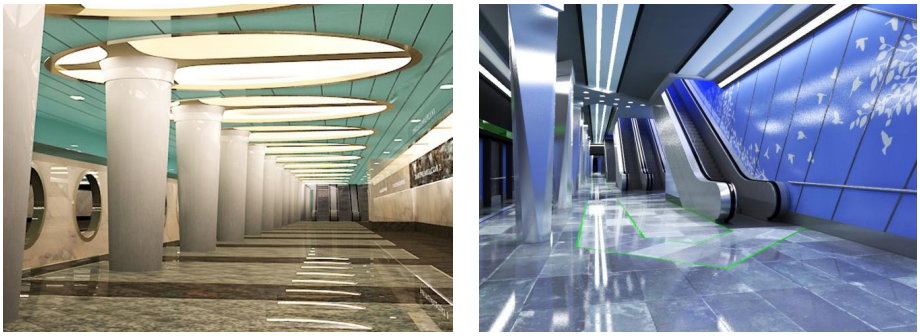

Fig.1. Subway stations with peripheral passenger platforms (Saint Petersburg, Moscow) .

A specific feature of space-planning solutions for stations at the two-way tunnel lines is such arrangement and zoning of passenger and service areas as to ensure optimal operation of utility systems providing safe exploitation of the stations. For instance, communication channels of the station ventilation and smoke removal systems occupy the isolated central zone and are directly connected to the passenger platforms.

One of the main utility systems supporting the subway operation is the ventilation system whose functioning should sustain creation of normative air parameters in running tunnels and at stations under standard conditions and also realization of emergency modes guaranteeing safe escape of people in emergency situations (e.g., fires) and subsequent elimination of the emergency (fire extinguishing).

2. Temperature regimes of the subway tunnels with typical-scheme ventilation

As the domestic and foreign experience shows, subway lines may comprise both single- and two-way tunnels. One of the possible ventilation schemes of single-way tunnels implies supplying the tunnels with outdoor air through a running-line plenum shaft, air motion towards the stations, and removal of a portion of air to the surface through the station exhaust vent shaft (Fig. 2) [3].