fire

Editorial

Smoke Movement and Control in Tunnels under Construction: Recent Research Progress and Future Directions

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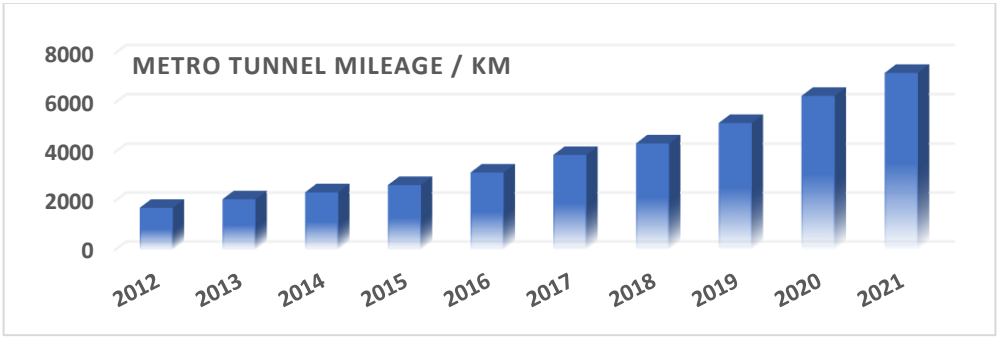
Introduction

China is the country with the largest number of tunnels, the largest tunnel construction scale, and the fastest development of tunnels in the world. Figure 1 shows the development history of metro and highway tunnels; it can be seen that tunnels have experienced rapid development in recent years. By the end of the year of 2021, there were a total of 23,268 highway tunnels, with a total length of 24,698.9 kilometers [1]; 7209.7 km of this distance is made up of tunnels operating the metro in China [2].



(**a**)

(**b**)

Figure 1. Tunnel development history: (**a**) metro tunnels; (**b**) highway tunnels.

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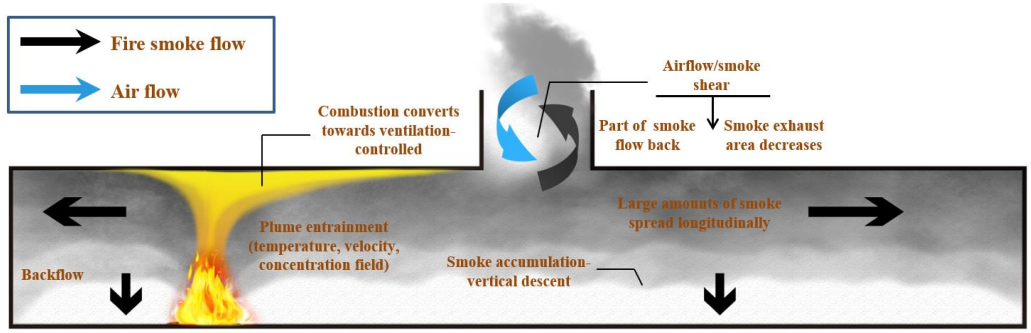
According to statistics from the International Tunneling and the Underground Space Association (ITA), in recent years, the tunnels under construction in China account for about 50% of the world's total tunnels under construction. The rapid development of tunnel construction has also brought significant fire safety hazards [3–5]. Ventilation and smoke extraction facilities in tunnels under construction cannot be set according to the requirements of the completed operating tunnel, and in the event of a fire, smoke is very difficult to control; the consequences of this are likely very serious. Figure 2 shows two typical structures of a tunnel under construction, and the typical characteristics of fire accidents. In the first scenario, the tunnel under construction consists of a vertical or inclined shaft (the construction passageway) and an excavation tunnel with two working faces. In the second scenario, one end of the tunnel under construction is the working face, and the other end is connected to the outside.



(**a**) Excavation at both sides

(**b**) Excavation at one side

Figure 2. Two typical structures of tunnels under construction, and the main characteristics of fire accidents.

Compared with an operating tunnel with openings at both ends, the structure of a tunnel under construction is more confined. The characteristics of fire and smoke spread in tunnels under construction are completely different from those in operating tunnels, and can be summarized as follows: (1) one or two ends of the tunnel are closed, and the accumulated combustion products cause the combustion to evolve dynamically, making it difficult to determine the combustion state of the fire (i.e., whether it is ventilation-controlled or fuel-controlled); (2) the air intake and smoke exhaust usually only pass through one portal at the same time, making it difficult to control smoke; meanwhile, it is likely that the smoke follows a longitudinal–vertical two-dimensional spread law.

In response to the fire characteristics of the above tunnels under construction, some scholars have studied the movement of smoke and the evolution of temperature through experimental and simulation methods [6–11].

For fire and smoke control and personnel evacuation in tunnels under construction, Yao et al. [11] proposed a simple improvement method for controlling smoke from fires in tunnels under construction, wherein a drainage device is placed in the middle of the construction passageway to divide the access for both natural ventilation and smoke exhaust, after which the temperature rise in the tunnel decreases significantly and the mass flow rate of the smoke through the construction passageway increases. Yuan et al. [12] invented a fire smoke control device for a single exit tunnel under construction by fully considering the particularity of having only one exit. Mehaddi [13] discussed the feasibility

and effectiveness of using fine water mist for smoke limitation and radiation shielding in the case of a fire in a tunnel under construction. The research group of Ingason [14,15] conducted a relatively systematic study on fires in tunnel under construction; their research content mainly concerns heat release rate, and evacuation and rescue operations.

This Special Issue touches on many issues central to understanding turbulent combustion and fire accidents in confined spaces [16–18]. These articles highlight the particularity and hazards of fires in confined spaces, which should receive widespread attention and be researched in depth. Potential research directions may include

(1) Special air entrainment characteristics and flame behaviors;
(2) The conditions of the transition from a fuel-controlled combustion state to a ventilation-controlled combustion state;
(3) Prediction models of smoke's longitudinal spread and vertical descent velocity;
(4) Efficient smoke exhaust devices and methods.

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