Research on the structure type of emergency rescue station in super-long railway tunnel

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Abstract. In order to ensure the safety of rescue and evacuation of super-long railway tunnel (longer than 20km), an emergency rescue station is generally set up. Through the research on the structure types of the railway tunnel and the railway tunnel group emergency rescue stations at home and abroad, the paper finds out the types of the emergency rescue stations and the advantages and disadvantages of different structural types. Conclusion are as follows, 1) Super-long railway tunnels in European countries, Japan and China generally adopt the form of double holes. Super-long railway tunnels generally use a single hole in China. 2) There are six types of structure of railway tunnel emergency rescue station: general encryption transverse channel type, horizontal guide type on both sides, single side flat guide type, refuge space type, encrypted horizontal channel type at the entrance and auxiliary tunnel type at the entrance.

1. Introduction

In recent years, the number of long railway tunnels has increased greatly, and disaster prevention and rescue evacuation of long railway tunnels has become the focus of scholars. Studies have shown that the construction of emergency rescue stations in super-long railway tunnels can greatly reduce the risk of train fires in super-long railway tunnels and ensure the safety of personnel evacuation. China stipulates[1] that tunnels or tunnel groups with a length of 20 km or more should be equipped with emergency rescue stations, and the distance between emergency rescue stations should not be greater than 20 km. European stipulates[2] that after the fire is determined, the passenger train meeting the long-term underground operation standard of passenger train shall be able to run normally for 20km. When the tunnel length exceeds 20 km, an emergency rescue station is required. Japan stipulates[3] that a double-hole subdivision scheme shall be adopted for tunnels over 30km, and emergency rescue stations shall not be provided for land railway tunnels under 30km. According to German regulations[4], it is required to carry out independent evaluation of its fire safety measures for long tunnel (L > 15km).

At present, there are various types of emergency rescue stations at home and abroad, and it is rare to have a unified expression and detailed analysis of their functional characteristics. Therefore, this paper analyzes the advantages and disadvantages of different types of emergency rescue stations and
their applicability by investigating the structural types of emergency rescue stations at home and abroad, and provides references for the selection of emergency rescue of long railway tunnels.

2. Structural types of emergency rescue stations at home and abroad

In order to have a better understanding of the structure of the railway tunnel rescue station, this article conducted a survey on its structure, the structure of the emergency rescue station is shown in Table 1[4]-[20].

| No. | Tunnel name            | Country             | Length(km) | Tunnel form             | Structure type               |
|-----|------------------------|---------------------|------------|-------------------------|------------------------------|
| 1   | Seikan Tonneru         | Japan               | 53.9       | Single hole double line | Two side flat guide type     |
| 2   | Larch Mountain Tunnel  | Switzerland         | 34         | Single-double hole      | Encrypted passage-way        |
| 3   | Young Dong Tunnel      | Korea               | 16.24      | Single hole double line | Encrypted passage-way        |
| 4   | Anglo-French Channel   | Britain and France  | 49.2       | Double hole single line | Encrypted passage-way        |
| 5   | San Diego Tunnel       | Switzerland         | 57         | Double hole single line | Encrypted passage-way        |
| 6   | Korlan Tunnel          | Austria             | 32.8       | Double hole single line | With evacuation space        |
| 7   | Guadarrama Tunnel      | Spain               | 28.2       | Double hole single line | Encrypted passage-way        |
| 8   | Pajares Tunnel         | Spain               | 24.6       | Double hole single line | Encrypted passage-way        |
| 9   | Wushaoling Tunnel      | China               | 20.05      | Double hole single line | With evacuation space        |
| 10  | Guanjiao Tunnel        | China               | 32.645     | Double hole single line | Encrypted passage-way        |
| 11  | Qingyunshan Tunnel     | China               | 22.175     | Double hole single line | Encrypted passage-way        |
| 12  | Xiangshan Super-long   | China               | 23.92      | Double hole single line | Encrypted passage-way        |
| 13  | Xiaoshan Tunnel        | China               | 22.759     | Double hole single line | Encrypted passage-way        |
| 14  | Qingtian Temple Tunnel | China               | 23.075     | Double hole single line | Single side flat guide       |
| 15  | Dangjinshan Tunnel     | China               | 20.100     | Single hole single line | Encrypted passage-way        |
| 16  | Gaoligong Tunnel       | China               | 34.53      | Single hole double line | Encrypted passage-way        |
| 17  | Liuyanghe Tunnel       | China               | 9.935      | Single hole double line | Two side flat guide type     |
| 18  | Yuntunbao Tunnel       | China               | 22.923     | Single hole double line | Two side flat guide type     |
| 19  | Dayaoshan Tunnel Group | China               | 24.7       | Single hole double line | Auxiliary tunnel at the entrance |
| 20  | Daqinling Tunnel Group | China               | 44.223     | Single hole double line | Auxiliary tunnel at the entrance |
| 21  | Tianhuashan Tunnel Group | China         | 42.365     | Single hole double line | Encrypted passage-way at the entrance |
| 22  | Furenshan Tunnel Group | China               | 24.686     | Single hole double line | Auxiliary tunnel at the entrance |
| 23  | Hejialiang Tunnel Group | China            | 37.656     | Single hole double line | Auxiliary tunnel at the entrance |
| 24  | Jinwen Railway Tunnel Group | China      | 23.213     | Single hole double line | Auxiliary tunnel at the entrance |
| 25  | Chenggui Line Tunnel Group | China       | 13.299     | Single hole double line | Auxiliary tunnel at the entrance |
| 26  | Zheng Wangao Three Gorges-Zhujiayan Tunnel Group | China | 25.98     | Single hole double line | Encrypted passage-way at the entrance |
| 27  | Qiling-Tianpingshan Tunnel Group | China | 21.057     | Single hole double line | Auxiliary tunnel at the entrance |
| 28  | Mountain-Nanliang Tunnel Group | China | 39.549     | Single-double hole | Auxiliary tunnel at the entrance |

It can be seen from Table 1 that there are two types of tunnel: single hole and double hole. The super-long railway tunnels in European countries, Japan generally adopt the double-hole form, while the super-long railway tunnel groups in China generally adopt the single-hole form.
It can be seen from Table 1 that the types of emergency rescue stations are divided into two types according to the different positions. The emergency rescue station in the tunnel includes four types of encrypted passage-way type, two side flat guide type, single side flat guide type and with evacuation space type. The emergency rescue station at the entrance of the tunnel includes an encrypted horizontal channel at the entrance and an auxiliary tunnel at the entrance.

3. Applicability, advantages and disadvantages of different types of emergency rescue stations

3.1. Emergency rescue station in the tunnel

3.1.1. Encrypted passage-way type emergency rescue station

The structure of the encrypted passage-way type emergency rescue station is shown in Figure 1. It is suitable for double-hole single-line railway tunnels. The advantage is that the existing structure is used for mutual rescue, and it is convenient for people to quickly escape to a safe tunnel after the accident; the disadvantage is that the amount of civil engineering is large and the cost is relatively high.

Figure 1. Encrypted passage-way emergency rescue station

3.1.2. Two side flat guide type emergency rescue station

The structure of the two side flat guide type emergency rescue station on both sides is shown in Figure 2. It is suitable for single-hole double-line railway tunnel. The advantage is that it is convenient for personnel to quickly evacuate and evacuate the accident tunnel, and avoid cross-line evacuation and improve safety. The disadvantage is that the amount of additional works is large.

Figure 2. Two side flat guide type emergency rescue station.

3.1.3. Single side flat guide type emergency rescue station

The structure of the single-side flat guide emergency rescue station is shown in Figure 3. It is suitable for single-hole single-line tunnels. The advantage is that it is easy for people to evacuate the accident tunnel. The disadvantage is that it needs to increase the amount of horizontal guide construction works, the cost is higher, and it is not conducive to external vehicles entering the rescue.

Figure 3. Single side flat guide type emergency rescue station.

3.1.4. With evacuation space type emergency rescue station

The structure of the emergency rescue station with refuge space is shown in Figure 4. It is suitable for double-hole single-line tunnels that cannot communicate with the outside world. A parallel guide pit can be set between the double-hole tunnels as a refuge space, or the transverse channel can be widened.
as a refuge space. The advantage is that it is convenient for personnel to wait for rescue. The disadvantage is the high cost and complicated construction.

Figure 4. With evacuation space type emergency rescue station.

3.2. Emergency rescue station between continuous tunnel portals

3.2.1. Encrypted passage-way at the entrance type emergency rescue station
The structure of the encrypted passage-way emergency rescue station at the entrance is shown in Figure 5. It is suitable for the double-hole railway tunnel group. The advantage is that the two parallel tunnels make full use of each other for rescue, and there is generally no external evacuation channel. The disadvantage is that multiple horizontal channels are encrypted, the engineering volume is large, and the cost is high.

Figure 5. Encrypted passage-way emergency rescue station.

3.2.2. Auxiliary tunnel at the entrance type emergency rescue station
The structure of the auxiliary tunnel at the entrance emergency rescue station is shown in Figure 6. It is suitable for single and double tunnels. The advantage is that the terrain conditions can be fully utilized, a small number of auxiliary tunnels or open evacuation channels are added, the cost is low, and personnel can be evacuated directly to a safe area outside the cave. The disadvantage is that the number of evacuation channels is small and the evacuation efficiency is low.

Figure 6. Auxiliary tunnel at the entrance type emergency rescue station.

4. Conclusion
The following main conclusions are obtained through research:
(1) The super-long railway tunnels in European countries, Japan generally adopt the double-hole form, while the super-long railway tunnel groups in China generally adopt the single-hole form;
(2) The emergency rescue station in the tunnel includes four types of encrypted passage-way type, two side flat guide type, single side flat guide type and with evacuation space type. The emergency rescue station at the entrance of the tunnel includes an encrypted horizontal channel at the entrance and an auxiliary tunnel at the entrance.

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