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## Investigation and Analysis on the Setting of Cross Passage and Auxiliary Passage in Extra-Long Highway Tunnel

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### Abstract

In order to meet the construction schedule, operation ventilation, escape and rescue requirements, a large number of auxiliary need to be set up in the construction of extra-long highway tunnels, the design parameters of vertical shaft, inclined shaft and parallel heading, cross passage are analyzed by investigation of the design on extra-long highway tunnels. The results show that parallel heading is usually adopted in tunnel with single hole two-way driving which it can be used as the auxiliary passage of the main tunnel during construction period and ventilation as well as rescue passage during operation period. The tunnel is generally divided into 2 sections by auxiliary passages in 3~5 km tunnels; 2~3 sections in 5~10km tunnels; 3~4 sections in tunnels over 10km. The angle of inclined shaft is mostly in 20°~25° which is usually set larger in actual engineering and the efficiency of construction and transportation is fully taken into account. In practical engineering of shafts longer than 400m, the shaft scheme needs to be studied to ensure the safety and economy of shaft structure.

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*Keywords:* extra-long highway tunnel, cross passage, shaft, inclined shaft, parallel heading

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### 1. Introduction

In recent years, with the rapid development of the national economy, more and more underground tunnels, such as traffic tunnels and underground powerhouse, have been developed to the "long, big and deep" trend [1-4]. In order to meet the construction schedule, operation ventilation, escape and rescue requirements, a large number of auxiliary passage such as shaft, inclined shaft, fan room and connected air duct need to be set up in the construction of extra-long highway tunnel, auxiliary passage has become a key part of construction and operation of extra-long highway tunnel [5-8]. At present, a lot of extra-long tunnel or tunnel group has been built or will be built in Shaanxi, Sichuan, Shanxi, Guizhou and other provinces. Among which, the longest highway tunnel in Asia, Shaanxi Nanshan tunnel is 18.6km in length and Shanxi Xishan tunnel is 13.6km; while Sichuan Nibashan tunnel 10km and Micangshan tunnel 10km, 13.8km as shown in Fig. 1 and Fig. 2. Meanwhile, some cross river and cross sea tunnels have also begun the design and construction, such as Qiongzhou Strait subsea tunnel, length of more than 30km, Bohai Bay tunnel length of more than 100km [9-13].

Based on the investigation of the design of auxiliary passage of highway tunnel (above 3km), the design parameters of vertical shaft, inclined and parallel heading, cross channel and auxiliary channel are to be analyzed, and the general rules for the future design and construction of the auxiliary channel is going to be summed up for further guidance needs in highway tunnel.

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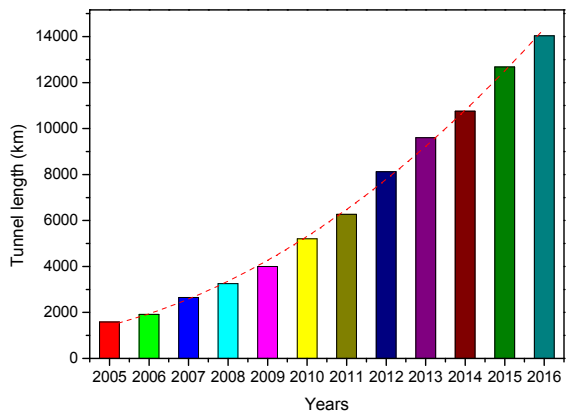


Fig. 1. The total length of highway tunnels in China from 2005 to 2016

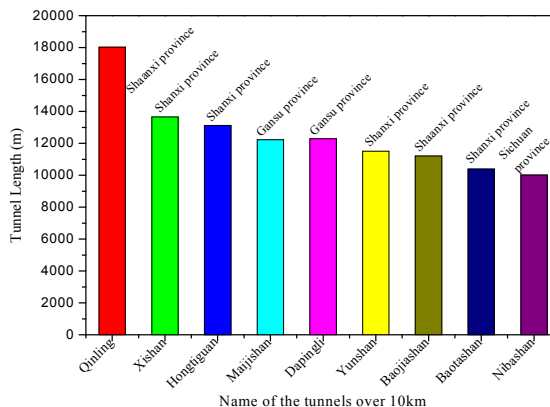


Fig. 2. Extra-long mountain tunnel in China

2. Investigation on cross passage spacing

The setting of cross passage spacing varies from different structure type, tunnel length, ventilation, smoke exhaust mode, design year of highway tunnel, and the cross passage spacing which includes 19 typical highway tunnels in China according to 3~5km, 5~10km and over 10km shown in Fig. 3. The maximum spacing of pedestrian cross passageway is 450m, and the minimum is 231m. In highway tunnels with a length of 3~5km, the maximum spacing of vehicle cross passageway is 720m, and the minimum is 462m. In the survey data, the pedestrian cross passageway spacing is the longest in Zhegushan tunnel and Huayingshan tunnel, the average is about 440~450m and the shortest is in Erlangshan tunnel with single hole two-way driving, the average is about 230m.

In highway tunnels with a length of 5~10km, the maximum spacing of pedestrian cross passageway is 400m, and the minimum is 250m. The maximum spacing of vehicle cross passageway is 830m, and the minimum is 700m. The pedestrian cross passageway spacing is the longest in Fangdoushan tunnel and the shortest is in Wuchiba tunnel and Yangjiao tunnel. For the two highway tunnels over 10km, the pedestrian cross passageway spacing in Linping tunnel is 350m and the vehicle cross passageway spacing is 1400m; The pedestrian cross passageway spacing in Zhongnanshan tunnel of Qinling is 250m and the vehicle cross passageway spacing is 700m.

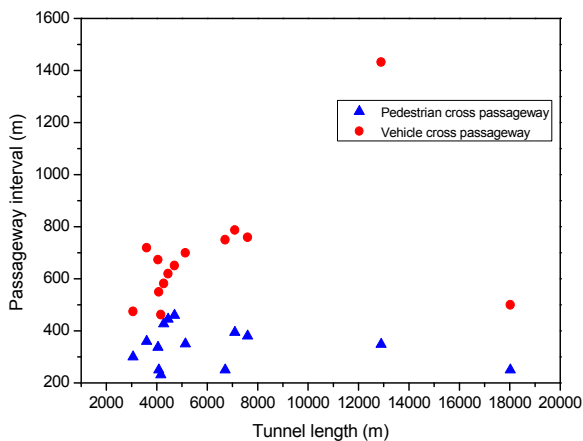


Fig. 3. Setting of cross passage in some domestic highway tunnels

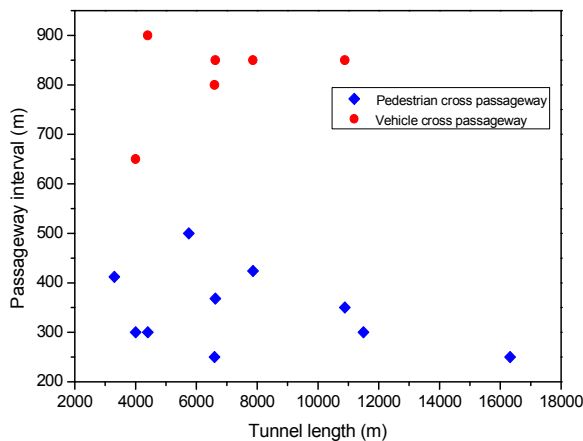


Fig. 4. Setting of cross passage in some abroad highway tunnels

The development of highway tunnels overseas is earlier than that in China, but the setting of the connected passage spacing is determined according to the actual conditions of each country, the spacing in different tunnel length varies greatly in different countries. The statistical data of the cross passage spacing of 16 foreign highway tunnels (except shield tunnels) are shown in Fig. 4.

In the highway tunnels of 3~5km, the longest spacing of pedestrian cross passageway is 400m in GA tunnel in Switzerland and the minimum spacing is 300m. In the highway tunnels of 5~10km, the longest spacing of pedestrian cross

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