

News & Highlights

A Statistical Analysis of China's Traffic Tunnel Development Data

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1. Introduction

Traffic tunnels include tunnel works for traffic and transport in the areas of railway, highway, and rail transit. With many mountains and nearly one fifth of the global population, China possesses numerous large cities and megapolises with rapidly growing economies and huge traffic demands. As a result, a great deal of railway, highway, and rail transit facilities are required in this country. In the past, the construction of these facilities mainly involved subgrade and bridge works; in recent years, given higher environmental requirements, implementation of the large-scale development of the western region, and worsening aboveground traffic jams in large cities, tunnel works are increasingly favored. Since the beginning of the 21st century, tunnel works in China have sharply increased. Incomplete statistics show that by 2016, a total of 30 000 km of traffic tunnels in China had been completed, and over 40 000 km of traffic tunnels were under construction or being planned [1,2]. China has become a true tunnel superpower.

2. Statistical analysis of railway tunnel development data

2.1. Overview of railway tunnels

By the end of 2016, the total length of railway tunnels in service in China exceeded 14 120 km, the length of railway tunnels under construction was about 9300 km, and the length of railway tunnels under design and planning was about 10 400 km [1,3]. By 2020, the total number of tunnels in service in China is expected to reach 17 000, with a total length of more than 20 000 km [1]; by 2030, the total length will exceed 30 000 km.

2.2. Overview of railway tunnels in service

Of the railway tunnels that are already in service in China, 102 extra-long tunnels (each longer than 10 km) add up to a total length of about 1411 km, and make up 10% of the total length of railway tunnels in service. Among these extra-long tunnels, nine tunnels (each longer than 20 km) add up to a total length of about 219 km. High-speed railway and inter-city railway tunnels add up to about 4080 km [4], or 28.9% of the total length of railway

tunnels in service. The longest railway tunnel in service is the New Guanjiào Tunnel on the Xining–Golmud section of the Qinghai–Tibet Railway, which is 32.6 km long, and the longest high-speed railway tunnel in service is the Taihang Mountain Tunnel on the Shijiazhuang–Taiyuan High-Speed Railway, which is 27.8 km long.

2.3. Overview of railway tunnels under construction

By the end of 2016, the total number of railway tunnels under construction was about 2400, adding up to a total length of about 9300 km. These include 742 medium-long tunnels (with lengths of 3–10 km), with a total length of about 4034 km, and 175 extra-long tunnels (each longer than 10 km), with a total length of about 2389 km. Of the latter, six tunnels are over 20 km long, with a total length of 150.5 km [1]. About 1600 high-speed and inter-city railway tunnels are under construction, with a total length of about 3450 km [4]; these make up about 40% of the total length of railway tunnels under construction. The longest railway tunnel under construction is the Gaoligong Mountain Tunnel between Dali and Ruili, which is 34.5 km long.

2.4. Overview of planned railway tunnels

Among the railway tunnels that are currently under design and planning, 801 are medium-long tunnels (with lengths of 3–10 km), adding up to a total length of about 4326 km. There are also 170 extra-long tunnels (each longer than 10 km), with a total length of about 2450 km; of these, 11 tunnels are over 20 km long, with a total length of 288 km. The number of planned high-speed and inter-city railway tunnels is 1922, adding up to a total length of about 4180 km; these make up 40.2% of the total length of planned railway tunnels [1].

2.5. Analysis of railway tunnel data

From an analysis of the statistics on China's railway tunnels, the following conclusions were drawn:

(1) Since the start of the 21st century, railway tunnels have entered a stage of rapid development. For more than 100 years, until 2000, the lengths of the completed railway tunnels in China

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added up to only 3820 km in total; however, in the 16 years from 2001 to 2016, an additional 10 300 km of railway tunnels were completed and put into operation.

(2) Extra-long tunnels keep getting longer. Before 2000, there were only three completed extra-long tunnels (each longer than 10 km) in China, with a total length of 45.5 km; however, in the 16 years from 2001 to 2016, 99 such tunnels were completed, with a total length of 1366 km. In addition, 175 extra-long tunnels are under construction, with a total length of about 2389 km, and 170 extra-long tunnels are being planned, with a total length of about 2450 km.

(3) The proportion of high-speed railway tunnels continues to grow. Before 2007, no high-speed railway tunnel was in service in the mainland of China; however, in less than 10 years, by the end of 2016, more than 4000 km of high-speed and inter-city railway tunnels were completed in China. Furthermore, of the 1082 km of railway tunnels that opened in 2016, 800 km were high-speed railway tunnels; these account for 73.9% of the total length of the new tunnels that were put into operation.

3. Statistical analysis of highway tunnel development data

By the end of 2016, 15 181 highway tunnels had been put into operation in China, with a total length of 14 040 km. Among these, 815 tunnels were longer than 3 km, adding up to a total length of 3622.7 km, and 3520 tunnels were 1–3 km in length, adding up to a total length of 6045.5 km [2,5]. The growth rate of the opening of highway tunnels in China in recent years is given in Fig. 1.

According to statistics [6], the total length of highway tunnels in China has grown by a rate of more than $1000 \text{ km}\cdot\text{a}^{-1}$, which is the fastest rate in the world. Of the ten expressway tunnels more than 10 km in length that have been completed around the world, nine are in China; furthermore, 18 expressway tunnels are under construction or will be constructed on the largest construction scale (in terms of excavation length) in the world. China has become a highway tunnel superpower, as is evidenced by the completion of super-long mountain tunnels such as the Qinling Zhongnan Mountain Tunnel, which is the longest two-tube expressway tunnel in the world; large-diameter

shield tunnels, such as the Chongming Yangtze Underwater Tunnel in Shanghai and river-crossing tunnels in Nanjing and Wuhan; under-river tunnels in Shanghai and Nanchang; and wide immersed tunnels, such as the undersea tunnel along the Hong Kong–Zhuhai–Macao Bridge.

4. Statistical analysis of rail transit tunnel data

By the end of 2016, a total of 133 urban rail transit lines had been opened in 30 cities in the mainland of China, with a total length of 4153 km; this included 2564 km of subway tunnels, which account for 61.7% of the total length of rail transit lines in China [7].

In 48 cities across China, 228 rail transit lines are under construction, with a total length of 5636.5 km, including 4925 km subway lines. Furthermore, incomplete statistics show that by the end of 2016, rail transit projects in 58 cities in the mainland of China had been approved, with a total length of about 7305 km under planning [7].

An analysis of data on rail transit tunnels in China showed that the share of subway tunnels in rail transit lines is growing. For example, of the additional 534.8 km rail transit lines that were built in 2016, 510.7 km or 95.5% belonged to subway works. The construction scale is growing rapidly and many Chinese cities have entered into a period of rapid development. The scale of planned construction also continues to grow.

5. Conclusions

Since the beginning of the 21st century, China has entered a peak period of traffic tunnel construction. Despite the brilliant achievements that have already been accomplished, many challenges remain. With the development of transport facilities in Western China, more tunnels will be built in general, tunnels of over 10 km in length will become the new normal [8], and more tunnels will be built to cross rivers or seas. China's tunnel engineers will encounter more complex geological conditions and environmental challenges. Relentless innovation in new technologies, materials, and equipment will provide broader prospects for technical progress in China's traffic tunnels.

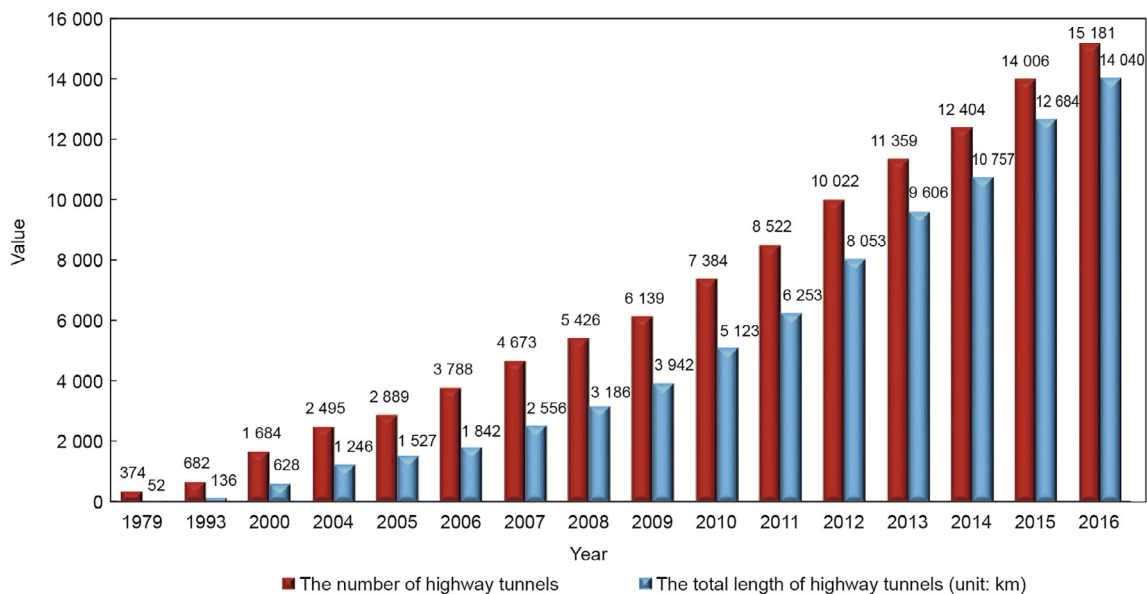


Fig. 1. Growth rate of the opening of highway tunnels in China in recent years.

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