

PRINCIPLES OF RAILWAY LOCATION AND DESIGN

SIRONG YI



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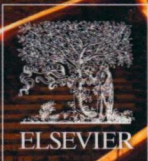
PRINCIPLES OF RAILWAY LOCATION AND DESIGN

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Principles of Railway Location and Design examines classification and classing methods of railway networks, covering theories and methods of railway route selection and design. This book introduces capacity-enhancing methods, implementation plans, and technical conditions for improving existing passenger railways, building new high-speed railways, and developing heavy-haul railways.

Areas of unfavorable geological conditions are discussed, detailing route selection principles and offering practical solutions. This valuable reference book covers basic principles and methods which are supported by engineering data and high-speed railway technology research in China.

Sirong Yi is a Professor at Southwest Jiaotong University. She currently oversees a program in railway route design, which won the honor of National Premium Program in China in 2005.



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Introduction

1 THE DEVELOPMENT OF RAILWAYS

As a huge achievement of modern civilization, railway develops with the science and technology. In the 1820s, the history of railway began as the invention of the steam locomotive and rail track.

The railway industry usually regarded the standard-gauge railway line from Stockton to Darlington, UK, which started on Sep. 27, 1825, as the very first railway line. This year is regarded as the birth of the world's railways. Up to now, the railway has a history of more than 190 years, and its development may be divided into four stages.

1) The early stage

The progress of science, technology, and commodity production have significantly affected the birth and development of railway. In 1804, Trevithick trialled the first steam locomotive which can run on rail track; in 1825, the first railway line of 32 km was constructed, as mentioned above. A total of 105,000 km of railway lines were constructed in the years 1825–1860. After the Industrial Revolution, the steam engine accelerated the development of transportation, and the railway was created. The United Kingdom constructed the first public railroad in the world, and then other western countries, such as the United States, France, Canada, Germany, and Italy all followed suit.

2) Peak stage

Railway lines developed the fastest before the First World War, from 1870 to 1913, when more than 20,000 km of railway were constructed per year, on average. The operating mileage of the world's railways was 1.104 million km by 1913, most of which were concentrated in the UK, the USA, Germany, France, and Russia. During this period, railway companies competed with each other by upgrading their speed. In 1903, an electric vehicle from Siemens-Halske recorded a speed of 210 km/h, the highest in that period.

3) Steady stage

In the period between the end of the First World War and the start of the Second World War, development of railways in main western countries had basically stopped. However, in colonial, semi-colonial, and sovereign countries, and independent countries, railways were developed rapidly. By 1940, the world's operating mileage reached 1.356 million km.

During the Second World War, railways in most European countries were destroyed and restored the old status before war until around 1955. After the Second World War, with the rapid development of highway and air transport, in major capitalist countries, railway faced intense competition with highway and aviation, and the proportion of railway passenger and freight traffic volume was reduced day by day. Many railway industries became unprofitable, with losses so severe that some countries had to take railway lines back under state control. The operating mileage has been consistent around 1.3 million km from the 1930s to the early 1960s.

2 Introduction

4) Modernization stage

The development of world railway began to recovery at the end of the 1960s, especially after the petrol crisis in the 1970s. Due to lower energy consumption than airplanes and automobiles, and less noise pollution, and higher transportation capacity, the railway was returned to as a main means of transportation. Electric traction was determined as the development direction. In the last 30 years, advanced technologies have been widely adopted, such as the revolution of traction power, development of container and piggyback transportation, improvement of communication signal, strengthen of track configuration, and development of management automation. We should note that the high-speed railway and heavy haul traffic are still developed.

Presently, there are about 140 countries and regions operating railway trains, and the overall operating mileage is about 1.2 million km (not including urban rail transport system). According to recent statistics, the top ten countries with longest operating mileage are 228,000 km of the USA, 121,000 km of China (no local railway included), 85,000 km of Russia, 64,000 km of India (state controlled), 52,000 km of Canada, 43,000 km of Germany, 39,700 km of Australia, 34,000 km of Argentina, 30,000 km of France, and 29,400 km of Brazil.

2 CONSTRUCTION AND PLANNING OF CHINA'S RAILWAY

China's railway is undergoing fast development, especially its high-speed railway. By now, the railway network in China totals 75,000 miles (120,000 km) and is predicted to reach 93,200 miles (150,000 km) by 2020. The train has been the top choice for more and more travelers in China. Every year, China's railway system accommodates over 2500 million passengers, and this number is still growing at a speed of about 10%.

The history of China's railways can be divided into three stages. The first stage, from 1865 to 1949, is featured as the awakening time; only a few railroads were constructed and in use. The second stage, from 1949 to 2004, is a massive construction stage when the old lines were restored and improved, and lots of new lines were built. It was during this stage that the country's railroad network took its shape gradually and was expanded to cover most cities in the country. In the third stage, since 2004, the country has entered the high-speed era. High-speed lines take place of old busy ordinary speed lines, which greatly increases transport capacity and makes train travel much easier than before.

About 150 years ago, the first train station was built in China. The first rail line in China was the Wusong Line, from Wusong to Shanghai with a length of 7.5 miles (12 km). It is regarded as the first chapter of the Chinese rail history. The real chapter of the rail history started with the local construction of the Tangxu Rail Line in 1881, from Tangshan to Xugezhuang. The first self-designed and constructed rail Line by China, Jingzhang Line (Beijing Fengtai to Zhangjiakou), was put into use in 1909, and was designed by the great rail engineer, Zhan Tianyou. He was appointed to be in charge of the rail construction, and the renowned Reversing Y-shape line was proposed by him, which was widely regarded as the most difficult project on account of the

geography barrier, hence Zhan Tianyou enjoys the fame of “The Father and General Engineer of Chinese Railway.” In the first place, before 1949, there were only about 14,602 miles (23,500 km) constructed and only 6835 miles (11,000 km) were in service. Most rail lines gathered in northeast and coastal area of China, with only 6% extending to other areas. Secondly, the standards of the rail line were different from each other in specification, for the lines were constructed by different countries. Therefore, the rail network was in a great mess.

After 1949, the rights to the railway were officially brought under state ownership and the Railway Ministry was founded to take charge. The railway construction developed according to the well scheduled plans and programming. The main lines were restored and connected and the construction work was done massively. The first task for Chinese railway career was to restore the main lines and standardize their operation. By the end of 1949, Jinghan, Longhai, Zhegan, Nantongpu, and Xianggui Railways were recovered, and nearly 5143 miles (8278 km) was open to traffic again.

Locomotives powered by electricity: In 1953, China started the first five-year development plan, and the enlargement of the railway network was given priority. In June of 1953, Chengyu Railway (Chengdu–Chongqing) was completed and put into use, and was the first railway built since the founding of new China. After that, Tiancheng, Tianlan, and Lanxin railways were accomplished one after another. By the end of 1957, the newly constructed rail lines amounted to 3790 miles (6100 km) as part of the plan, which strengthened the links between China’s interior and its east coast. It also consolidated communication with neighboring countries, such as Vietnam and Mongolia. However, in 1958, the railway construction work was affected again, and the railway operating order was disturbed gravely as a consequence of trying to achieve too much too soon. Sadly, this also resulted in an increased number of rail accidents. The major focus on coal and mineral freight disadvantaged the transportation of crops and light industrial products which had detrimental effects on the economy. From 1961 to 1965, these problems were overcome, and the railway regained stable improvement and rectification. In 1961, Baofeng (Baoji–Fengzhou) section of Baocheng Railway (Baoji–Chengdu) was finished as the first electrified railway. However, China railway suffered another disaster during the decade from 1966 to 1976. Several of the most important rail terminals were blocked, and the transport and freight suspended for a while. In 1968, the whole undertaking hit rock bottom. From 1978, large resources were put into modernization of the network, and the disproportion in the railway development was readjusted. After long-term restoration and recovery, the development of the rail system regained a good momentum. After the Third Plenary Session in 1978, the railway electrification process was accelerated greatly. Xiangyu, Shitai, Baolan and Chengyu lines were gradually electrified. In just 24 years or so, China had constructed 41 electrified rail lines, with a total length of 11,567 miles (18,615 km). In general, the railway networks extended in all directions during this stage; most finished rail lines were put into operation; the passenger volume and freight forged ahead; while the railway management was inclined to be more scientific in its approach to the overall organization. The entire rail operation developed at a steady pace as it marched forward into the 21st century.

With the rapid economic development, China's railway capacity is persistently overtaken by demand, especially in the developed economic zones. This makes it urgent for bringing more capacity into service by stepping up high-speed lines construction. In 2004, the State Council approved the Mid-to-long Term Rail Network Plan, ensuring that construction of high-speed lines receives priority. This program led to the construction of a high-speed rail network consisting of four north-south lines and four east-west lines, which connects with most part of the country, namely several intercity high-speed lines among economic regions, such as Bohai Sea Coastal Region, Yangtze River Delta, and Pearl River Delta Economic Zone. Huge investments are put into the construction project. Upgrading and electrifying the existing lines runs in parallel with new additions. In 2007, the Sixth Railway Speed-up plan had addressed the call for increasing transport capacity. Some of the busiest lines were upgraded to accommodate top speed of 124–155 mile/h (200–250 km/h).

In 2008, the high-speed era dawned on domestic travels with the operation of China's first high speed line, Beijing-Tianjin Intercity High Speed Railway. In 2009, the Wuhan-Guangzhou section of world's longest high-speed line, Beijing-Guangzhou High Speed Railway opened. In 2010, Zhengzhou-Luoyang-Xian High Speed Rail Line was operational. In 2011, the Beijing-Shanghai High Speed Railway was inaugurated. And the travel time between the two cities was cut to about 5 h from 15 h. In 2012, the first frigid Harbin-Dalian High Speed Line was functional, and by the end of that year, the high-speed lines had totaled 5800 miles (9350 km). In 2013, the Ningbo-Hangzhou, Panjing-Yingkou, and Nanchang-Putian high-speed lines followed each other into service. The Four North-South and Four East-West Network has taken shape. In 2014, Lanzhou-Xinjiang, Nanning-Guangzhou, Guangzhou-Guiyang, Taiyuan-Xian section of Datong-Xian, Hangzhou-Changsha section of Shanghai-Kunming, as well as Chengdu-Leshan-Emeishan high-speed lines all became reality. In 2015, Chengdu-Chongqing, west line of Haikou-Sanya, Hefei-Fuzhou, Jilin-Hunchun, and Nanjing-Anqing high-speed rails were all put into operation. In 2016, Zhengzhou-Xuzhou, Shanghai-Kunming, Guangzhou-Kunming high-speed rail lines will all be opened. China has attained the acme of high-speed railway development, for it has achieved the broadest, fastest, and most advanced high-speed rail network in the world. About 75,000 miles (120,000 km) tracks were in use and over 12,500 miles (20,000 km) were the high-speed type. In addition, China's advanced high-speed technology has come of age in the international arena. Plans of collaborative high-speed rail ventures with foreign regional governments have been made to project China's technical knowhow abroad, including the China-Pakistan Line, China-Thailand Line, China-Laos Line, China-Myanmar Line, and China-Nepal Line.

China's railway network has a total length of 75,000 miles (120,000 km), among which 12,500 miles (20,000 km) are high-speed railways. These railways shape a dense net covering almost every corner of China, even remote mountainous areas, Tibet on the "Roof of the World," and Hainan Island on the sea. By 2030, the railway network in China is expected to reach 93,200 miles (150,000 km). First of all, we will introduce several major normal-speed railways, including five vertical lines running in a north-south direction and three horizontal lines traversing in