Engineering Structures 100 (2015) 707–717

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Review article

Recent development of design and construction of short span high-speed railway bridges in China

Bin Yan [1], Gong-Lian Dai [1], Nan Hu [*,2]

School of Civil Engineering, Central South University, Changsha, Hunan 410075, China

ARTICLE INFO

Article history:
Received 23 February 2014
Revised 26 June 2015
Accepted 29 June 2015
Available online 10 July 2015

Keywords:
High-speed rail
Bridges
Short span
Design
Construction

ABSTRACT

High-speed rail (HSR) has become a vital component of the national transportation network in China. A large number of standard short-span bridges were constructed as part of the infrastructure associated with the HSR development. The main focus of this short review is to showcase how the fast HSR construction in China during the past decade was achieved by using typical simply supported bridges and continuous beam bridges. This paper provides a brief historical review of the HSR development in China along with emerging design issues. Design concepts and structural dimensions of two typical spans are discussed, including the superstructure, substructure as well as the auxiliary facilities on the bridge deck. Different construction methods were also discussed.

Contents

1. Introduction . . . 707
2. Brief history . . . 708
3. General design issues . . . 710
   3.1. Live load . . . 710
   3.2. Serviceability limits . . . 711
   3.3. Other issues . . . 711
4. Typical superstructure . . . 712
   4.1. Simply supported beam . . . 712
   4.2. Continuous beam . . . 713
   4.3. Deck system . . . 715
5. Typical substructure . . . 715
6. Typical construction method . . . 716
7. Summary . . . 716
   Acknowledgements . . . 716
   References . . . 716

1. Introduction

High-speed Rail (HSR) offers a fast and robust travel option that enhances the quality of life and supports economic growth. Japan was the first country that built a passenger dedicated line (PDL) for high-speed travel purpose, also known as Shinkansen. The first Shinkansen opened for the Tokyo Olympics in 1964 between Tokyo and Osaka. HSR in Europe first developed in several countries and then has expanded into a regional service network. Over the past

* Corresponding author at: College of Engineering, Michigan State University, MI 48824, USA.
E-mail addresses: binyan@csu.edu.cn (B. Yan), daigong@vip.sina.com (G.-L. Dai), hunan2@msu.edu (N. Hu).
[1] Equal contribution.
[2] Former graduate student researcher at Central South University and currently, postdoctoral research fellow at Dartmouth College.

http://dx.doi.org/10.1016/j.engstruct.2015.06.050
0141-0296/

few decades, a total of 13 countries have developed HSR network, mainly in Europe and East Asia. International examples from those countries have proved that high-speed trains are capable of reaching a speed over 250 km/h on a PDL, which can significantly reduce travel hours. A detailed historical review about the HSR development in those countries can be found in papers by Taniguchi [1], Bouley [2], the European Commission [3], Gourvish [4], Zuber [5], and Harrison et al. [6].

The worldwide HSR construction is still an ongoing process which many countries have proposed future plans for developing HSR networks, such as in USA and in Australia [7–10]. A survey data collected by the International Union of Railways (UIC) indicates that China is currently the leading country on HSR construction, as shown in Fig. 1. HSR in China is composed of upgraded existing lines with an average design speed of 250 km/h and new lines with an average design speed of 350 km/h. Specifically, it includes 9356 km of new built lines and 3209 km of upgraded lines. By 2020, the total length of HSR lines in China will reach more than 20,000 km with a complete grid network that will connect major provincial capital cities as well as large cities with more than five million population [11]. During the past decade, fast expansion of the HSR network in China depended on the supports of government policy, the increases in fiscal investment and the growths of expertise. The planning and construction of the HSR network in China was aimed to solve the overcrowding issue on the regular railway system. HSR offers additional advantages, such as reduction in greenhouse gas emissions over other travel options, as compared in Fig. 2. Thus, HSR revolutionized travel experience

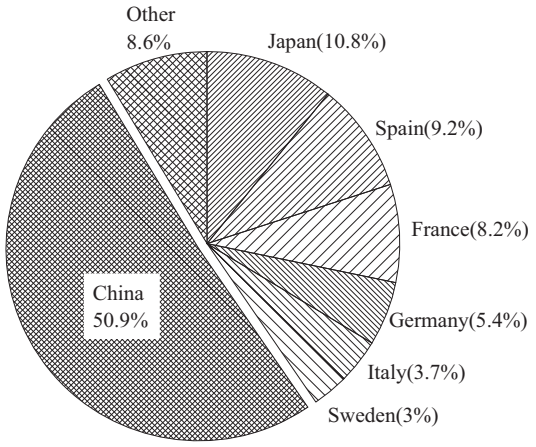

Fig. 1. HSR mileage by countries [11].

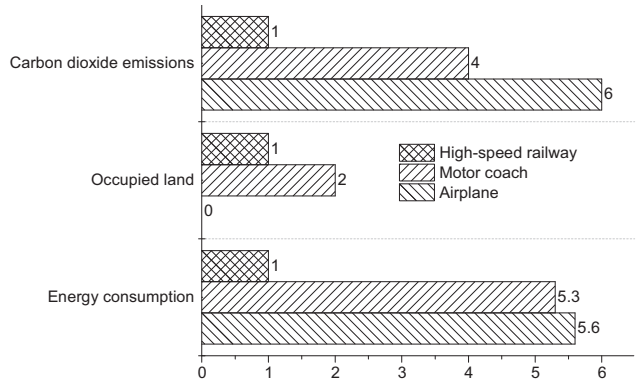

Fig. 2. Dimensionless comparison of sustainability issues on three travel options [16].

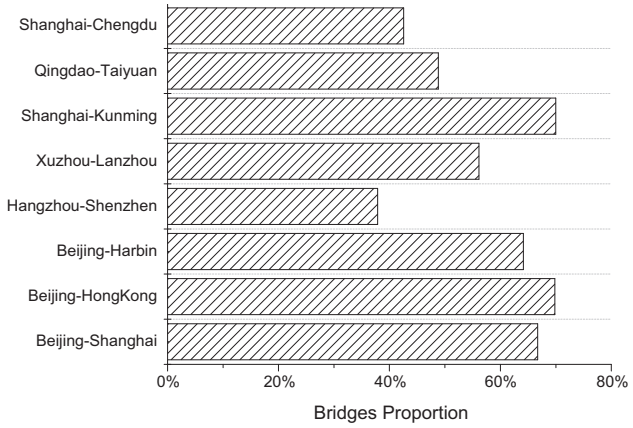

Fig. 3. The percent of bridges in the infrastructure of major HSR lines of China.

and local economic growth by providing an efficient means of direct, high-speed transportation for individuals and businesses in China.

Bridges are a major part of the HSR infrastructure, covering more than 50% of total HSR mileage in China because the use of bridges can avoid the interruption of existing lines and the occupation of land [12]. Fig. 3 lists the proportions of bridge with respect to the total length in major HSR lines of China [13]. Fast construction usually requires using a typical structural design, along with construction details and procedures. Several key design features are compared between typical short HSR bridges from six countries in Table 1. A typical PDL in China usually includes a big portion of simply supported beam bridges, a few continuous beam bridges and a few middle/long span bridges (usually single span more than 100 m) over existing lines or rivers. For example, the Beijing–Shanghai PDL includes 90% simply supported beam along with 5% continuous beam and only 5% are medium/long spans [14]. In the Chinese HSR bridge design specification, short span is defined as a bridge with a single span smaller than 30 m. It can be seen in Table 1 that two typical structural types in a HSR line of China are simply supported beam and continuous beam. The design and construction of these two structural types has been improved over the years and eventually been considered as a mature industrial product. As a result, rapid design–construction process can be achieved by using a full set of construction drawing, building steps and maintenance plan.

The objective of this paper is to present an up-to-date review on the emerging design and construction techniques about HSR bridges in China, particularly on short spans (including standard simply support beam and continuous beam). Another companion paper [15] has been published in an earlier issue by *Engineering Structures* that focused on the medium and large span HSR bridges. This review will showcase how the use of typical design has contributed in promoting HSR bridge to a highly industrialized product. This paper includes a brief history of HSR in China followed by an introduction of special issues that emerged in the design of HSR bridges. Technical issues on the design and construction of typical short span HSR bridges are discussed, including superstructure, substructure and deck system. Information for this review is partially collected from design companies in China and partially from the literatures.

2. Brief history

The HSR development in China can be divided into five main phases [16]: (1) from early 1980s to 1993, a decade-long feasible study period by policy makers from the former Ministry of Railways (MOR) of China; (2) from 1994 to 1997, a three-year