

Recent Achievements and Challenge of Long Span Bridges in China

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ISSN: 2639-0574



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Submission:  May 21, 2019

Published:  May 23, 2019

Volume 3 - Issue 2

How to cite this article: Hongmei T, Xiuping W. Recent Achievements and Challenge of Long Span Bridges in China. *Adv Civil Eng Tech.* 3(2). ACET.000559.2019.
DOI: [10.31031/ACET.2019.03.000559](https://doi.org/10.31031/ACET.2019.03.000559)

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Opinion

Recently, bridges are becoming longer, wider and more sophisticated in China and over the world, in particular, with longer span length or so-called long span bridges. Nevertheless, achievements and challenge are coexisting in girder, arch, cable-stayed and suspension types.

Long span girder bridges

Girder bridges are most widely used bridge type with three sub-categories, simply supported system, continuous system and continuous rigid frame system. The current longest span of simply supported beam bridge is only 76m while continuous beam bridge has the longest span of 165m. Continuous rigid frame bridge has the shortest history but the greatest bridging capacity in girder bridges. The span length of this type of girder bridge firstly exceeded 250m in Humen Bridge of 270m China in 1997, and gradually increased to 330m in the 2nd Shibampo Bridge in China in 2006.

For the 2nd Shibampo Bridge, the box girder bridge's long span was made economically and technologically feasible by using steel-concrete hybrid structures, within which a 103m steel box girder in the middle of the 330 m main span, is connecting monolithically to the concrete box girder to reduce the weight of the structure. Therefore, the maximum hogging moment of the 330m spanned hybrid girder is about the same as the 270m spanned Humen Secondary Bridge with PC girder. However, the challenging problems encountered in prestressed concrete girder bridges are related to extreme bending moment, PC girder excessive deflection and orthotropic steel deck cracking.

Besides the traditional methods to reduce shrinkage and creep of concrete and anti-crack in PC webs, one of the most innovative ways is to adopt corrugated steel webs or steel truss webs in PC box girder, which can cut down 20~40% girder weight. In China, there are more than 300PC box girder bridges with corrugated steel webs since 2005, while more than 100 bridges with steel truss webs.

Arch bridges

China has an ancient history of arch bridge construction for about 2,000 years, and the oldest existing bridge is Zhaozhou Bridge of 605AD, which is the world's first wholly-stone open spandrel segmental arch bridge. In the past two decades, China has built several remarkable arch bridges with very long spans, including stone arch ribs (146m Danhe Bridge), concrete arch ribs (445m Beipanjiang Bridge), concrete-filled steel tube arch ribs (530m Bosideng Bridge), steel box arch ribs (550m Lupu Bridge) and steel truss arch ribs (552m Chaotianmen Bridge).

CFST (concrete-filled steel tube arch ribs) is an advanced steel-concrete composite structure with an external steel tube and internal filled plain concrete. The local stability of a steel tube is improved by the concrete filling it; besides, the toughness and strength of the concrete are improved by the external confinement of the steel tube. During the past 20 years, more than 400 CFST arch bridges have been constructed in China, with a maximum span of

530 m. And now, a bridge call the third Pingnan Bridge is under construction, with a main span 560m. Arch bridges still have their own compressive challenges in buckling and/or instability of long span arch ribs and large horizontal resistance in foundation.

Cable-stayed bridges

In this century, the span length of cable-stayed Bridges over 1km was realized in the 1088m Sutong Bridge in 2008, the 1018m Stonecutters Bridge in 2009 and the 1104m Russky Bridge in 2012, respectively. The construction of cable-stayed bridges began in China in 1975. Since then more than 300 cable stayed bridges have been completed, and over 85% of them have been built with prestressed or reinforced concrete decks. According to the statistics, among long-span concrete cable-stayed bridges, the longest span length is 500m in Jinsha Yangtze River Bridge in Hubei Province completed in 2002.

Among long-span concrete cable-stayed bridges, more than half of them have been found in cracking of concrete decks with various cracks, which become the most challenge problem of structural durability. Through various investigations, most cracks can be identified in top plates, bottom plates, web plates and diaphragms.

The current cable-stayed bridge types with spatial cable planes and closed box girder may support to enlarged main span up to 1,400m if the challenging problems of deck lateral bucking and stay cable vibration can be overcome.

Suspension bridges

Suspension Bridge is the old but longest type among these four types of bridge. Now, the longest box girder suspension bridge in the world is Xihoumen Bridge in China, a two-span suspension bridge with a main span of 1650 m. For the purpose of wind resistance, for aerodynamic flutter stability, twin-box steel girder is adopted in this bridge. In which, the two boxes relate to a box section beam and an I-shaped beam at an interval of 18m corresponding to the spacing of the bridge hangers.

In suspension bridge construction, the pilot rope pulling plays a very important role. There are many kinds of methods for pulling the pilot rope in China: using a tugboat, by helicopter, using rocket, and using unmanned aerial vehicle. The most challenging problem in suspension bridges is aerodynamic instability or so-called flutter, and some control measures must be adopted.

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