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History of Cable-Stayed Bridges

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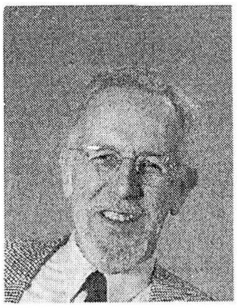

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Abstract

The principle of supporting a bridge deck by inclined tension members leading to towers on either side of the span has been known for centuries but it did not become an interesting option until the beginning of the 19th century when wrought iron bars, and later steel wires, with a reliable tensile strength were developed. A limited number of bridges based on the stayed girder system were built – and more proposed – but the system was never generally accepted at that time.

In the second half of the 19th century a considerable number of bridges were built with a cable system comprising a suspension system with parabolic main cables and vertical hangers as well as stay cables radiating from the pylon tops. As an example, Fig.1 shows the Albert Bridge across the Thames in London. In this bridge from 1873 both the parabolic top 'cable' and the stays were made of eye bar chains.

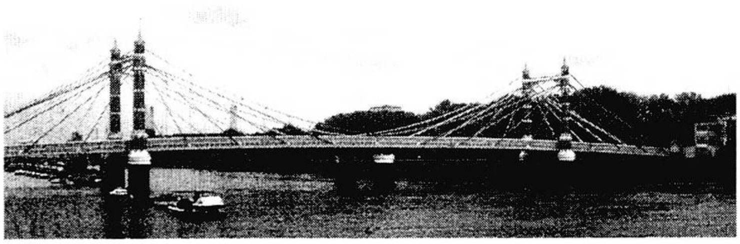

Fig.1 The Albert Bridge across the Thames in London.

The combination of the suspension and the stayed system was also applied in a number of bridges built in France in the 1880s, but the most notable bridges of this type were designed by *John A. Roebling* and built in the United States – among these the longest cable supported bridge of the 19th century: the Brooklyn Bridge.

Cable-stayed bridges as we know them today, i.e. self anchored systems with compression in the deck, were built in France already in the beginning of the 20th century but the Strömsund Bridge in Sweden is generally regarded as the first modern cable-stayed bridge where the efficiency of all cables in the final structure as well as a favorable distribution of dead load moments in the deck is achieved by carefully analysing the erection process.

After the Strömsund Bridge the next true cable-stayed bridge to be erected was the Theodor Heuss Bridge across the Rhine at Düsseldorf. During the 1960s this bridge was followed by many others in Germany where all the major developments took place for over a decade. Among these developments, the introduction of the multi-cable system was of special significance as it simplified the erection procedure and made it easier to design the bridge for stay cable replacements.
These advantages should subsequently result in a general acceptance of the multi-cable system in almost all cable-stayed bridges. However, in that process it should later be realized that the multi-

cable system also presented some disadvantages such as a higher vulnerability to excitations and increased total wind load on the cable system.

Another important development during the 'German Era' was the first application of parallel-wire monocable strands (in the Mannheim-Ludwigshafen Bridge from 1972).

The German cable-stayed bridges were dominated by steel as structural material not only in the cables and the girders but also in the deck plate (orthotropic deck) and the pylons.

Cable-stayed concrete bridges were few during the first decades of the cable-stayed bridge development. However, as a remarkable exception a cable-stayed bridge of unusual proportions had been completed already in 1962: The Maracaibo Bridge in Venezuela. Here both the pylons and the deck girder were made of concrete..

During the 1970s the concrete cable-stayed bridges were further developed and often they proved to be competitive to steel bridges. The first multi-cable concrete bridge was the Brotonne Bridge across the Seine but it was soon followed by many others.

In 1984 the completion of the Barrios de Luna Bridge in Spain gave a further indication of the competitiveness of concrete as structural. With a main span of 440 m the Barrios de Luna Bridge became for a couple of years the record-holder amongst cable-stayed bridges.

During the 1980s the development also included composite girders and for a period of five years the Alex Fraser Bridge with its main span of 465 m became the record-holder.

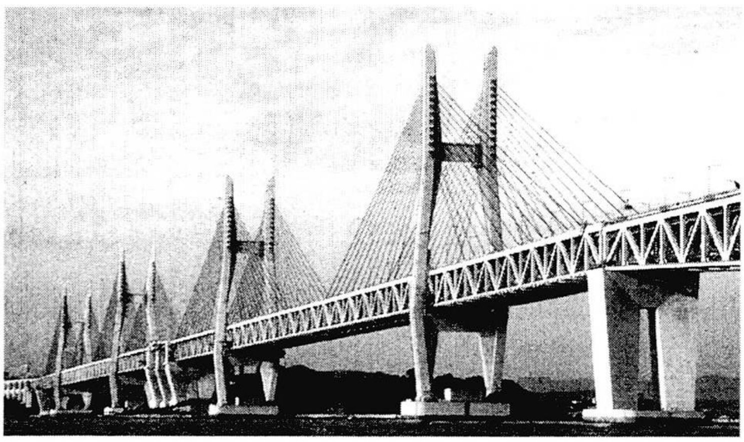

Fig.2 The Hitsuishijima and Iwagurojima Bridges

In Japan the development of cable-stayed bridges comprised the Rokko Bridge, the first double deck cable-stayed bridge, and later in a much larger scale, the double deck concept was used for the twin cable-stayed bridges, the Hitsuishijima and the Iwagurojima Bridges (Fig.2) forming a part of the Seto Ohashi between Honshu and Shikoku. These bridges carry a four-lane expressway on the upper deck and a double track railway - with provisions for a later addition of two more tracks on the lower deck.

In Tokyo a tricky design problem was overcome in the late 1980s by constructing the world's first S-curved cable-stayed bridge (the Katsuhika Harp Bridge).

During the 1990s the development of the cable-stayed bridges have continued and a substantial increase of the span range has occurred. Also, during this decade the geographical point of gravity has switched. Thus, in 2000 seven of the ten longest cable-stayed bridges will be found in the Far East (China and Japan).