Fifty years of Bridge History

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Summary

Looking at the past, several key innovations in the field of bridge engineering and technology are worth mentioning: the prefabrication of concrete box girders in short sections, match cast and assembled using a well adapted equipment, which has become the best way to build short and medium span bridges; the combination of external prestressing and optimized steel-concrete composite decks made of concrete slabs connected to steel trusses or corrugated webs, a promising technique for spans up to 250 meters; the development of the necessary calculation tools for the design and safe erection of cable-stayed bridges, which offer a large variety of appearances and presently lead to exceptional achievements all over the world. Indeed, bridges to be built in the future will be gigantic, impressive, light and heavy, deep and high, wide and long. They will be challenging major straits, mitigating natural disasters, fighting the power of the wind, of the sea, of the earth, but linking people, countries, continents. They will have to be erected within a short time to improve our daily life as quickly as possible; they will have to be durable and easily maintained. The fantastic boom of the past fifty years in the field of structural engineering will have to be improved in such a way that our infrastructures become definitely sustainable.

Keywords: Cable-stayed bridges; composite decks; durability; external prestressing; innovations, maintenance; prefabrication.

1. Introduction

If we look at the past, in terms of centuries, the most significant evolution which has been made in the field of structural engineering and more especially in the field of bridges is related to the materials and combination of materials.

Of course, structures and forms have been simultaneously adapted to the evolution of resistant materials and corresponding technologies leading to the fantastic development of many structural concepts, including cable stayed bridges, while old construction methods were improved, or new ones developed, thanks to the imagination of construction engineers.

2. The Past

From this point of view, it must be recognized that, since they have been imagined fifty years ago, Prefabrication of concrete box girders in short segments and Balanced Cantilever Assembly using PT tendons of these prefabricated elements across bridge supports have definitely marked the construction of bridges. This was indeed an opportunity for structural engineers to imagine and progressively develop some powerful assembly techniques by using cranes, beam and winch systems or launching gantries which are today commonly used all around the world.

It was towards the latter part of the seventies that the first spectacular applications of external pre-stressing, combined with innovative construction methods, were to be seen.

The progressive construction method with temporary stay cables is based on a very simple idea. It consists of placing the prefabricated segments of a deck continuously, from the first abutment to the

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other one. As an alternate, assembling the segments span-by-span on a truss was used for the first time as many long bridges located in a marine environment had to be reconstructed in the Florida Keys (USA); this was a first step towards many successful and powerful techniques; this was the step from light to the heavy prefabrication.

3. From Past to Present

3.1 Cable stayed bridges

But the structural concept which marked the last part of the twentieth century in the field of bridges was clearly the combination of bridge decks and stay cables.

The first modern cable-stayed bridges consisted of steel decks built using free cantilever construction, supported by a small number of stay cables. The idea was to make long spans feasible by replacing expensive intermediate supports by active supporting cables. As a result, stay cables were big units generating large forces at anchorages and steel decks had to resist large bending moments during erection.

Using smaller cables regularly distributed along the deck was therefore a major improvement as it was then possible to optimize the span-to-depth ratio of the deck structure. In addition, the idea rapidly appeared as being an extension of the classical post-tensioned tendon layout of concrete bridges, in which PT tendons are placed outside the concrete deck with increased eccentricities; it lead to the design of long span concrete bridges:

Steel and concrete have also been associated in various ways. This includes classic bridge types as well as cable-stayed bridges. To what degree steel and concrete can be used cooperatively depends on the width of the deck, the span arrangement and main span length, the number of cable planes and the available construction methods. Thanks to an appropriate combination of both materials, main spans of the Normandie (France) and Tatara (Japan) cable stayed bridges were the first to reach the 900 meters.

3.2 Long links and long span bridges

Several major fixed links and long span bridges have been built during the last fifteen years thanks to the development and the integration of powerful construction methods into the design of these structures. The most famous of them are the Second Severn Crossing (UK), the Confederation Bridge (Canada), the Oresund crossing, the Rion-Antirion Bridge and the Millau viaduct.

4. Present

The concept of cable-stayed bridges has considerably extended the field of Structural Engineering to the design of many crossings which were not possible in the past. Cable-stayed bridges offer a large variety of appearances and presently lead to exceptional achievements all over the world. Today, cable-stayed bridges are at the origin of a long list of major achievements, with spans ranging from six hundred to more than eleven hundred meters; with the Sutong Bridge across the Yangtze River (China) and the Russky Island Bridge (Russia), it has to be pointed out that, in less than twenty years, the length of the longest span has almost been doubled. Today, Extradosed bridges, as a result of a compromise between classical bridges and cable-stayed bridges are experiencing a fantastic development all over the world.

5. Towards the Future

Present challenges will lead unavoidably to the construction of long links and long span bridges which will reduce the distances between people, the cost of transportation and the necessary time to travel around the world.

The way this is going to be achieved can be seen from the progress made in design and construction methods. Gigantism is not a fact; it is a need to erect major links, quickly, economically, and safely.