Bridge construction - An overview

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The article briefly traces the history of bridge building right from the beginning of human civilisation to the modern era. The author argues that in the field of bridge engineering, India has made considerable advances, which are in many respects, comparable to those of the advanced countries.

The history of bridge building can be traced to the beginning of human civilisation. The need for a bridge arose out of necessity when the human beings, in search of food, came across an obstacle in the form of a channel or a water course. Observation of naturally-made bridges such as tree trunk fallen across a stream or an arch of stone formed by erosion of soil below it or a bunch of creepers from one tree to the other used by monkeys might have given the basic idea for bridge building. The human beings soon learnt how to cross hurdles such as a small water course by placing a piece of log or by tying a bunch of long creeper with the trees situated on either side of the water course. That formed the very beginning of the bridge building which in course of centuries developed continuously due to humankind's efforts to build bridges of longer spans and using different materials. Simultaneously, aesthetics has also been given immense importance, so much so that bridge building has come to be treated as an art.

Early bridges

The earliest bridge on record was the bridge over the river Nile built by Menes, the King of Egypt about 2650 BC. Five centuries later, another bridge was built by Queen Semiramio of Babylon across the river Euphrates. Timber was used in many of the ancient bridges because of the great ease with which it can be obtained and worked with. Although in the beginning, the structural form used in the form of a natural stone slab or a timber was what can today be called as a girder bridge, it soon gave way to a more complex arch shape. The introduction of the arch making, use of soft sand stone and bricks made possible even the construction of comparatively larger span bridges. Primitive arch type bridges were built long before the Christian era in Persia, Greece, France and Mesapotamia. The oldest existing arch dating back to about 350 BC and consisting of 20 pointed arches each of 7.5-m span is at Khorsbad in Babylonia. The Romans were the first to take up bridge construction in a systematic manner and some of the masonry arch bridges and viaducts built by them exist even today.

Modern bridges

The era of modern bridges started in the 18th century when timber gave place to iron as the building material. The first iron bridge of 30.5-m span was built in 1779 over the Severn in Coalbrookdale, England. Although cast iron was used in the beginning, it was soon replaced by wrought iron and then in course of time by steel, when Bessemier process of steel making was introduced. Simultaneously, scientific theories were evolved about the behaviour of various structural forms. This, coupled with the improvement in the quality of steel, resulted in rapid development in the construction of larg-espan bridges, particularly the suspension as well as large-span cantilever bridges. In the 19th century, manufacture of heavy load lifting equipment and high-capacity compressors made pneumatic sinking of caissons in deep water possible, and as a result, construction of large spans in deep water could also be taken up.

Concrete bridges

By the end of 19th century concrete made its entry in the field of bridge construction. Due to its versatility in use, economy in construction and ease in maintenance, it soon gained popularity. With concrete as the building material it was possible to cast elements of a bridge in any convenient shape and can therefore meet the architectural requirements, while at the same time using the locally-available material such as gravel and sand. Construction can be done right at site unlike steel bridges which require fabrication in a workshop,

transportation later to the site followed by the assembly of various components and erection. It is for this reason that reinforced concrete soon replaced steel in the construction of small and medium-span bridges. Slabs and the slab and girder (T-beam) systems using reinforced concrete became popular during the period 1930 to 1940. It was not until 1930, that prestressed concrete was used for bridge decks, a notable example being a design by Fritz Leonhardt for a single span 30-m crossing of a German Autobahn in 1938. Due to the shortage of steel, there was a rapid development in the use of prestressed concrete after the Second World War. Its use for larger span bridges became popular with the advent of high-strength concrete and high tensile steel wires.

The strides made in understanding the behaviour of different structural forms in the past two hundred years or so have made it possible to design and construct a variety of structures using steel, reinforced concrete and prestressed concrete. While the beam-type structures were originally simply supported, it was possible to make the span continuous over two or more supports as solutions became available to analyse such structural systems. This in itself has evolved a number of construction procedures to produce an economic solution for the given site conditions. Balanced cantilever method is one such method used popularly for continuous bridges. Method of incremental launching by means of a launching girder is another method adopted for launching of long-span continuous bridges. These construction methods may use either precast segments or in-situ segments or a combination of both. In India, the balanced cantilever method has been used in the construction of the road bridge at Tejpur. However, in this case it is a statically determinate structure with a suspended span used for closing the gap across the two cantilever arms. This road bridge with a cantilever span of 52.5m and the suspended span of 15m was opened for traffic in 1987 and is a tribute to the technical excellence of the Indian engineers.

Suspension bridges

Suspension bridge is somewhat like an arch form turned upside down. It is one of the forms of bridge construction known to the human beings from the advent of the civilisation --- though in a much primitive form compared to the suspension bridges built in the past 150 years or so. This form is much lighter than any other bridge forms to carry the same loads over the same span. The construction of suspension bridges got perfected with the use of steel for the superstructure as well as in the manufacture of cables. George Washington Bridge across Hudson River, Brooklyn Bridge in New York and Golden Gate Bridge in San Fransisco are some of the monumental bridge structures serving even today. With this form of construction, bridge engineers have been able to attempt much larger spans as were not imagined earlier. Many of these bridges were record-breaking achievements at the time of their construction.

Cable-stayed bridges

A recent addition to the development of modern bridges is the cable-stayed bridge. This has proved to be more economical and stiffer than the suspension bridge. Applied to steel structures initially, this approach gained immediate acceptance in the field of concrete bridges also. One of the longest cable-stayed bridges was completed recently over river Hooghly at Calcutta. This bridge has a main span of 457m with two side spans of 183m, thus making this bridge length equal to 823m.

Construction of the third Godavari Railway Bridge is another feather in the cap of Indian engineers. It is perhaps for the first time any where in the world that a bow-string arch girder using concrete has been constructed for such a long span as 97.55m, and that too for the railway loading which is much heavier compared to the highway loading to which most of the landmark bridges in the advanced countries are built.

Indian scenario

Execution of such long-span bridges as Brahmaputra Bridge at Tezpur, cable-stayed bridge at Calcutta, the 5.575-km long Mahatma Gandhi Setu across the Ganga near Patna demonstrates clearly that the Indian engineers are not lagging behind the bridge engineers in more advanced countries. Construction of the third Godavari Railway Bridge is another feather in their cap. It is perhaps for the first time any where in the world that a bow-string arch girder using concrete has been constructed for such a long span as 97.55m, and that too for the railway loading which is much heavier compared to the highway loading to which most of the landmark bridges in the advanced countries are built. Building of 28 such spans is even a more challenging task. Here came together the design expertise of Swiss engineers and the construction expertise of the Indian engineers to evolve an architecturally-elegant, structurally-efficient and functionally-superior structure to serve the needs of Indian Railways for the next century and more.

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