Journal of Advances and Scholarly Researches in Allied Education
Vol. XIV, Issue No. 2, January-2018, ISSN 2230-7540

A Study of Various types of Bridges in India with Historical Perspective

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Abstract – Bridges are structures which are built over an obstacle like valley, water or road with the purpose of making a transportation route. Bridges lay horizontally between some types of supports. These are used for transportation of vertical loads. The important aspect of a bridge is that it does not provide any kind of hindrance to the route beneath it. In the beginning bridges were very simple structures that were built from easily accessible natural resources- wooden logs, stone and dirt. Because of that, they had ability only to span very close distances, and their structural integrity was not high because mortar was not yet invented and rain slowly but constantly dissolved dirt fillings of the bridge. Evolution also came in the field of Bridge construction. They can be classified in many ways, such as on the basis of the construction material used, the style, or the mechanism for holding weight, etc. However, they are most commonly differentiated on the basis of their mechanism for bearing weight. The present paper is an attempt to study the various types of bridges in India namely cantilever bridges, arched bridges, extradosed bridges and cable-styled bridges and their history.

Key Words: Bridge, cantilever bridge, arched bridge, extradosed bridge and cable-styled bridge.

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HISTORY OF INDIAN BRIDGES:

A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley. In other words, bridge is a structure for carrying the road traffic or other moving loads over a depression or obstruction such as channel, road or railway. A bridge is an arrangement made to cross an obstacle in the form of a low ground or a stream or a river without closing the way beneath. With the population of over 1.2 billion and vehicular traffic of over 100 million, it becomes impossible to move the travelers and goods down the places without an adequate quantity of roads and flyovers / bridges / multilevel interchanges. There were times when alternate routes were located wherever the desired shorter route encountered a deep gorge, tall mountain or continuous flowing river. With the advent to engineering knowledge gain by the civil engineering fraternity, these barriers have been broken and structural solutions such as long span bridges, underpasses, tunnels etc. have been employed. The world has taken a giant leap in the field of long span bridges, creating world record of 2km span Akshi – Kaikyo Bridge. The techniques, generally, used for long span bridges are Cantilever Construction (50m to 300m span), Arch bridge (20m to 600m span), Extra dosed bridge (50m to 250m span), Cable Stayed bridge (100m to 1500m span), Suspension bridge (150m to 2000m span) etc. India has also been following world trends in construction of long span bridges. These bridges are constructed for vehicular road traffic, rail traffic, freight traffic, army traffic and even air traffic (runway over bridge). There are many grounds to classify the types of bridges. The present paper has included the study of *cantilever bridges, arched bridges, extradosed bridges and cable-styled bridges.*

CANTILEVER BRIDGES:

A cantilever bridge is formed of cantilevers projecting from supporting piers. The ends of a cantilever bridge are treated as fixed. They are quiet similar in appearance to arch bridges. However, they support the load through diagonal bracing. Usually, they feature a truss formation in both below and upward parts of the bridge. They are also considered as a modified form of Beam Bridge. However, the support lies at the middle area of the span. A cantilever bridge combines the advantages of a simply supported span and a continuous span. For long spans and deep valleys and at places where it will not be practicable to use centering, cantilever bridges are more suitable. They are suitable in case of uneven settlement of foundation. The construction of a cantilever bridge may either be of simple type or of balanced type.

The size and weight capacity of the cantilever bridge impact the number of segments it uses.

Cantilever Bridge

India has constructed several cantilever construction bridges with spans up to 160m. Some of them are:

A. 102m spans bridge for Jammu-Udhampur Rail Link (JURL) in North India with piers as tall as 70m. The bridge comprises ballasted deck (heavy loading). Due to the heavier loading and certain stress control requirements for enhanced durability, the superstructure is as deep as 9.5m at the pier location. These are located in the highest seismic zone of the country. Therefore, a Site Specific Response Spectra was prepared for an adequate seismic design of the bridge.

B. 160m Span Akhnoorbridge (North India) for Boarder Road & Organisation (BRO). The bridge holds Indian record of largest span constructed by Balanced Cantilever Construction. Depth of the 12m wide M50 concrete box girder varies from 3.4m at mid span to 9.75m at the pier location. The bridge also incorporates STUs for seismic control. The 60m long end spans have been filled up with PCC to mobilise weight against uplifting of the abutment bearings.

C. 84m span bridge of Barapullah Viaduct New Delhi over railway tracks of Northern Railways. The precast segmental cantilever construction bridge is the first Indian bridge that has made use of Specialized Segment Lifter with the capability of moving with 100T segment over already constructed part of the bridge and lowering the segment after rotating it. It may be noted that segments were not allowed to be transported from railway tracks side, yet a balanced cantilever bridge could be constructed.

D. 500m long continuous span module involving 100m span cantilever construction precast segmental bridge over river Ganga in Allahabad, Uttar Pradesh. Long continuous supported over well foundations has been provided with STUs (Shok Transmission Units) at two piers in addition to fixed POT bearings at one pier.So that, during seismic activity, three piers can temporarily act as fixed piers in order to share the large quantum of longitudinal forces.

Arch Bridges

Arch bridges have been an ancient form of bridge structure that provides an excellent combination of aesthetics and large span. It is referred to as an arch bridge as it is shaped in the form of arch rather than straight structure. The arch structure lies beneath the bridge. These bridges were also constructed a long time back. They have good natural strength. The load is pushed outward and downward due to curved pattern. The force does not remain same throughout the bridge surface, but it is pushed towards the end supports. A bridge with multiple arches beneath the surface is also a common type of arch type bridges. Tied arch bridges, Corbel arch bridge, Aqueducts and Canal viaducts, Deck arch bridge, Through arch bridge and Tied arch bridge are also some variants of arch bridges. India is not far behind in this filed.

Arch Bridge

A. 524m span steel arch bridge in Jammu & Kashmir is already in planning. The following bridges have been gracefully commissioned.

B. Dodan Nallah arch bridge with a small span of 40m has been constructed in Himachal Pradesh (North India). The bridge is fully in Reinforced Cement Concrete (RCC). It has won several awards for its aesthetic matching with the surroundings. Almost every element of the bridge, that includes arch rib, spandrels and deck have been provided with a small thickness of 30 cm, making it sleek and working as a foreground to the greenery in the surroundings.

C. Third Godawari Arch Bridge with the span of 97m has been constructed for Indian Railways at Rajahmundry (South India). The bridge comprises several spans in the concrete arch with the under slung Prestressed concrete deck suspended through wire hangers. As the deck is located at the eaves of the arch rib, it has been designed and detailed to take the longitudinal thrust of the arch ribs. The bridge over water is famous for its spectacular features.

D. 120m span Jia Arch bridge over river Parvati in Himachal Pradesh (North India). The bridge is located over turbulent river Parvati, where no ground supported staging can be provided for construction of concrete arch rib. The construction has been carried out by innovative technology of stay cantilevering for 120mspan, two nos. parallel concrete arch ribs, using temporary steel pylons and temporary stay cables and under slung form traveler. Subsequent to the arch ribs, the RCC deck has been constructed with the help of formwork hanging from the arch ribs through wire hangers, which later be-came the permanent hangers. The project has employed large well foundations of 13m x 26m in the rocky substrata.

EXTRADOSED BRIDGES:

An extradosed bridge employs a structure which combines the main elements of both a prestressed box girder bridgeand a cable-stayed bridge. The name comes from the word extrados, the exterior or upper curve of an arch, and refers to how the "stay cables" on an extradosed bridge are not considered as such in the design, but are instead treated as external prestressing tendons deviating upward from the deck. In this concept they remain part of (and define the upper limit of) the main bridge superstructure. Compared to a cable-stayed or cantilever-girder bridge of comparable span, an extradosed bridge uses much shorter stay-towers or pylons than the cable-stayed bridge, and a significantly shallower deck/girder structure than used on the girder bridge. This arrangement results in the typical extradosed "look" of a fan of low, shallow-angle stay cables, usually with a pronounced "open window" region extending from the sides of each tower.

The Extradosed Bridge

A. The extradosal bridge form is mostly suited to medium-length spans between 100 metres (330 ft) and 250 metres (820 ft), and over fifty such bridges had been constructed around the world to 2012. Whilst incurring many of the construction costs of both the cable-stayed and girder bridge types, extradosed bridges can deliver material savings to offset much of this penalty. They have frequently been adopted when overall height, navigation clearance, or aesthetic requirements have made the cable-stayed or girder alternatives less feasible Extradosed bridges are no more a far off dream in India. Several of them with spans ranging up to 100m have been constructed.

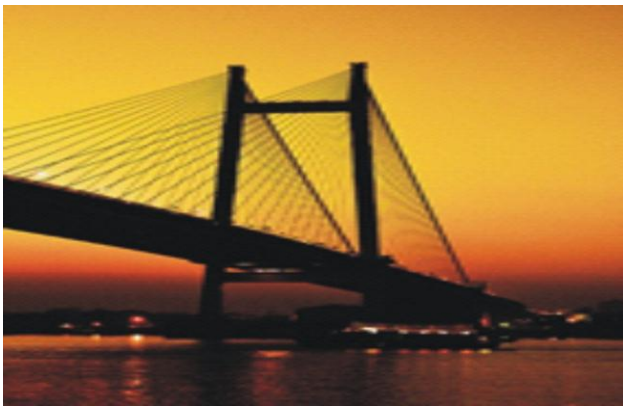
B. Extradosed bridge at Moolchand, New Delhi with the span of 65m is one live example in the capital of India. As the bridge carries twin tracks of Delhi Metro, it has been provided with the central plane of cables and central pylons. Challenges of this precast segmental bridge include construction over an existing vehicular underpass at Ring Road and existing parallel close-by flyover in constrained spaces. Specialised VSL saddles have been used for stay cables connection at the pylons.

C. 880m long Second Vivekananda Extradosed bridge (also called Nivedita Bridge) over river Hooghly in Kolkata (East India) has been constructed with several spans of 110m. The bridge comprises widest single deck of 27m in India. As the bridge carries twin carriageways, it has been provided with central row of pylons& cables. Interesting feature used in the

bridge is the provision of hinge beams at the middle of the bridge length. The each of the two steel hinge beams uses 8 nos. bearing (4 above and 4 below) in order to permit longitudinal translations, yet arrest the vertical movements between the two adjoining cantilevers.

CABLE STAYED BRIDGES:

Today cable-stayed bridges are a popular design that is often used for spanning medium to long distances that are longer than those of cantilever bridges but shorter than the longest suspension bridges. The most common build materials are steel or concrete pylons, post-tensioned concrete box girders and steel rope. These bridges can support almost every type of decking (only not including heavy rail) and are used extensively all around the world in several construction variations. They use deck cables that are directly connected to one or more vertical columns (called towers or pylons) that can be erected near abutments or in the middle of the span of the bridge structure. Cables are usually connected to columns in two ways – harp design (each cable is attached to the different point of the column, creating the harp-like "strings" and "fan" designs (all cables connect to one point at the top of the column). This is a very different type of cable-driven suspension than in suspension bridges, where decking is held with vertical suspenders that go up to main support cable.



Cable Stayed Bridge

A. India takes pride in having constructed cable-stayed bridge of span of 457m which is half as much as Japan's largest cable-stayed span of 890m (Tatara bridge). VidayaSagar Setu on Hooghly River in Kolkata (East India) uses Conventional two pairs of pylons, used to support the 35m wide composite deck through cables.

B. 250m span cable-stayed bridge under construction over river Yamuna in Delhi has been named "Signature Bridge". This innovative bridge comprises single one sided pylon as used for Alamilo Cable Stayed bridge in Spain and Erasmus bridge in Rotterdam, Holland. The steel pylon, specially fabricated in China and assembled in India uses plates as thick as 120mm and a large number of HSFG bolts. The deck comprises the steel-concrete composite structure. Similar to Erasmus bridge, pylon has been provided with back stays connected to the deep open foundation to take the longitudinal pull.

CONCLUSIONS:

Bridge is not a construction but it is a concept, the concept of crossing over large spans of land or huge masses of water, and to connect two far-off points, eventually reducing the distance between them. The bridge provides passage over the obstacle of small caverns, a valley, road, body of water, or other physical obstacle. Designs of bridges vary depending on the nature of the terrain and the function of the bridge and where it is constructed. It may be well appreciated that India has constructed numerous medium to large span bridges across the country. Perhaps the needs are more, but due to various economic and planning reasons, demand has not been fulfilled. India has a history of constructing a large number of Cantilever Construction bridges and Arch bridges. However, several Extradosed bridges have also been constructed for road and metro rail traffic. Cable-stayed bridge of 457m central span is truly an achievement for India.

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