Third Godavari Bridge - An overview

G. V. Ratnam

The third Godavari Bridge, having 28 spans of 97.552-m length, is nearing completion. The bridge is resting on double 'D' shaped well foundations and solid concrete piers. It has an innovative bow-string arch girder superstructure constructed in concrete. The article presents a broad overview of the project.

The railway line linking Howrah and Madras is one of the main arteries on the Indian Railways network. Vijayawada-Waltair section of South Central Railway forms a part of this line. It crosses river Godavari about 175 km from Vijayawada near the pilgrim town of Rajahmundry. River Godavari is the longest river in south India and the second longest in India, next only to the mighty Ganga. The river flows through tortuous terrain consisting of hilly areas till it comes to Rajahmundry where it enters plains.

The width of the river increases to about 3 km near Rajahmundry where the railway line crosses the river. A bridge to cross the river by the railway line was built and opened for traffic as early as 1900. To cater to the needs of ever increasing traffic on Vijayawada-Waltair section a second railway line was also built. The second bridge was built as a road-cum-rail bridge and it was the longest of its kind when it was inaugurated by Mr Fakruddin Ali Ahmed, the then President of India in the year 1974.

Necessity of third bridge

Since the time the first bridge was built, the traffic on the section increased many-fold. Due to fatigue, a number of diagonals of the first bridge trusses started showing signs of distress in the form of cracks near the rivet holes. A highly restrictive speed limit of 15 km/ hr had to be imposed on the bridge affecting the traffic movement on this highly saturated route. The time had come when its replacement had become inevitable. A decision was therefore taken to build a third bridge in lieu of the first bridge. The new bridge which was sanctioned at a cost of Rs 297.7 million was started in the year 1981. Figure 1 shows a key plan highlighting the location of the three bridges.

The third bridge is located 54m up-stream of the centre line of the existing first bridge. The alignment had to be chosen taking into account the necessity of connecting the two towns of Kovvur and Rajahmundry on either side of the river and to avoid sharp curves as are existing on the approaches of the second bridge. The approaches of the second bridge, namely the road-cum-rail bridge, are laid in a curve of 5 degree curvature on Kovvur side and 6 degree curve on Rajahmundry side, restricting the speed to 60 km/hr. To avoid such speed constrictions and to avoid acquisition of densely populated areas of the town, the alignment of the third bridge has been chosen parallel to the first bridge.

The substructure for the new bridge caters for two tracks, although at present, the superstructure for only one track is being built. A second superstructure will be provided at a future date when the traffic necessitates the same. It can, however, be built avoiding the acquisition of land.

Span arrangement

The old bridge consists of 56 spans of 46m (150 ft) each. In the third bridge however, it was decided to provide 28 spans. New piers are located opposite to the existing piers skipping every alternate pier. This gives a clear span of 92.552 m, Figure 2. The bridge was conceived with double D-well foundations and mass concrete piers of size suitable to locate two girders. The superstructure proposed was a K-type truss with corrosion resistant Carten steel. The same type of steel was used for the third Krishna bridge built near Vijayawada. Use of corrosion-resistant steel was necessary in view of proximity to the sea.

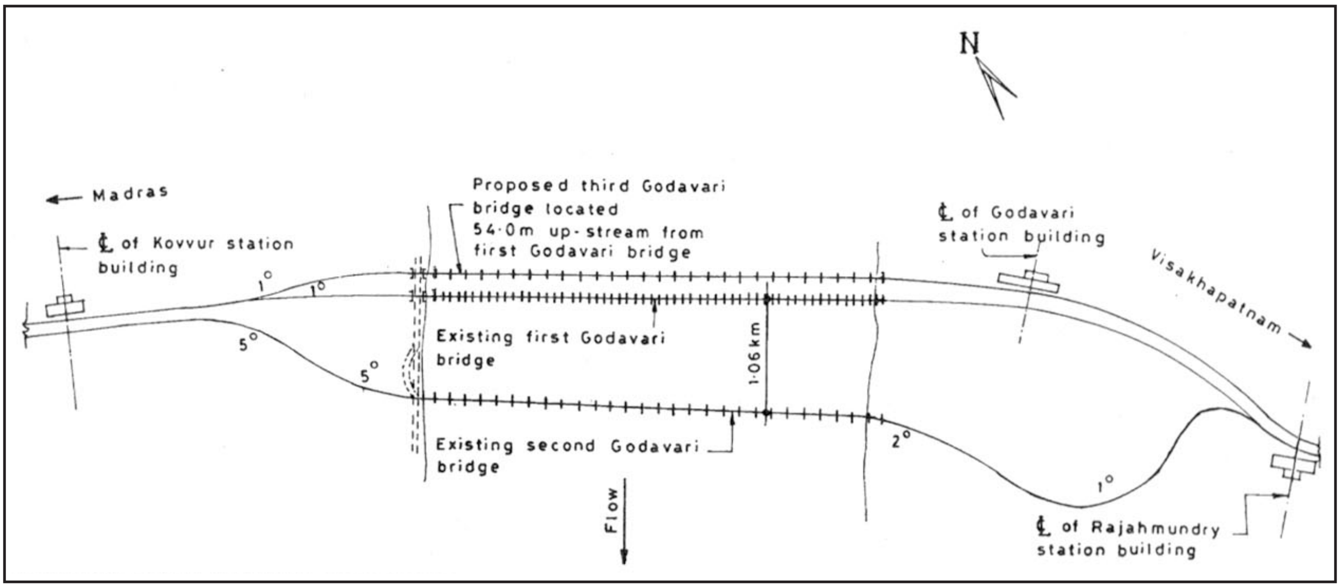

Figure 1. Key plan showing locations of three bridges on river Godavari near Rajahmundry

Steel and concrete alternatives for superstructure

Although originally a steel superstructure was conceived for this bridge, this was re-examined due to the growing popularity of concrete deck bridges on the Indian Railways. Compared to wooden sleeper track or steel channel sleepers provided on large span girders, ballasted deck bridges offer several advantages. The track structure provided on the bridge proper will be similar to that provided on approaches which lead to improved riding conditions besides several other benefits. During 1980s, Railways therefore started adopting prestressed concrete bridges with ballasted deck for longer spans, which were hitherto not attempted. While in the past individual spans upto 24.4 m were adopted using prestressed concrete, spans of 30.5m (Aroor Bridge on Southern Railway), 45m (Vasai Creek Bridge on Western Railway) and 53m (Thane Creek Bridge for Metropolitan Transport Project, Bombay) were successfully used later on.

It was therefore decided to explore the possibilities of using a prestressed concrete bridge of suitable design to realise the advantages of ballasted deck for the third Godavari Bridge. While ballasted deck could be used with steel truss design, it would be too heavy and uneconomical. The already completed foundation and substructure were checked for their adequacy in case of adoption of a prestressed concrete superstructure and were found to be suitable.

In view of the importance of the structure and the magnitude of the work involved, South Central Railway decided to prequalify contractors for both concrete girder as well as steel girder option so that in case the Railways find the concrete option unsuitable for its requirements, it could go ahead and adopt the steel girder without any loss of time. Based on prequalification, three firms were found suitable for the steel option and two firms for the concrete option.

Evaluation of bids

Based on the design criteria adopted for other prestressed concrete railway bridges using international codes such as BS 5400 and UIC Codes, draft design criteria were prepared and circulated to the prequalified firms, RDSO and the Railway Board. Based on the comments received from these sources the design criteria were finalised. Thereafter the tender schedules along with special conditions of contract were prepared and were finalised in consultation with the prequalified firms and with the approval of Railway Board. In the case of the steel girder option the firms were asked to quote their offers for the

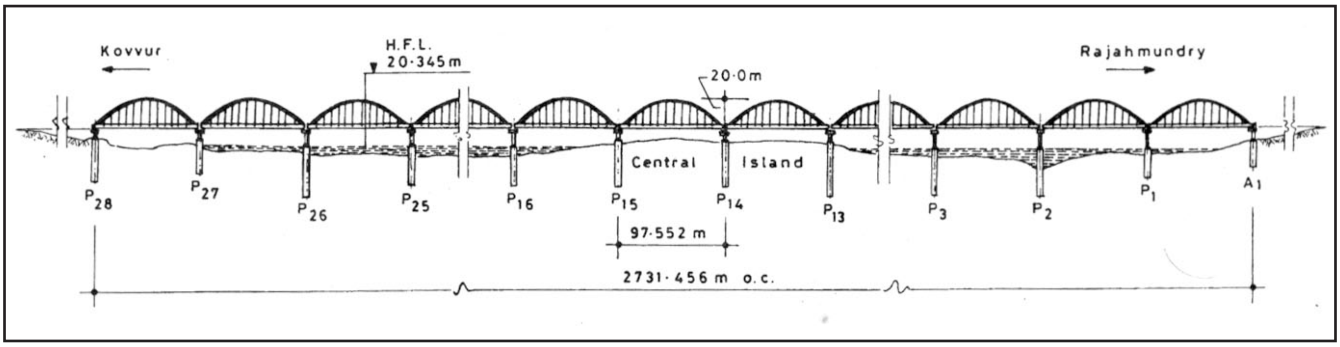

Figure 2. Longitudinal section of the third Godavari Bridge showing span arrangement

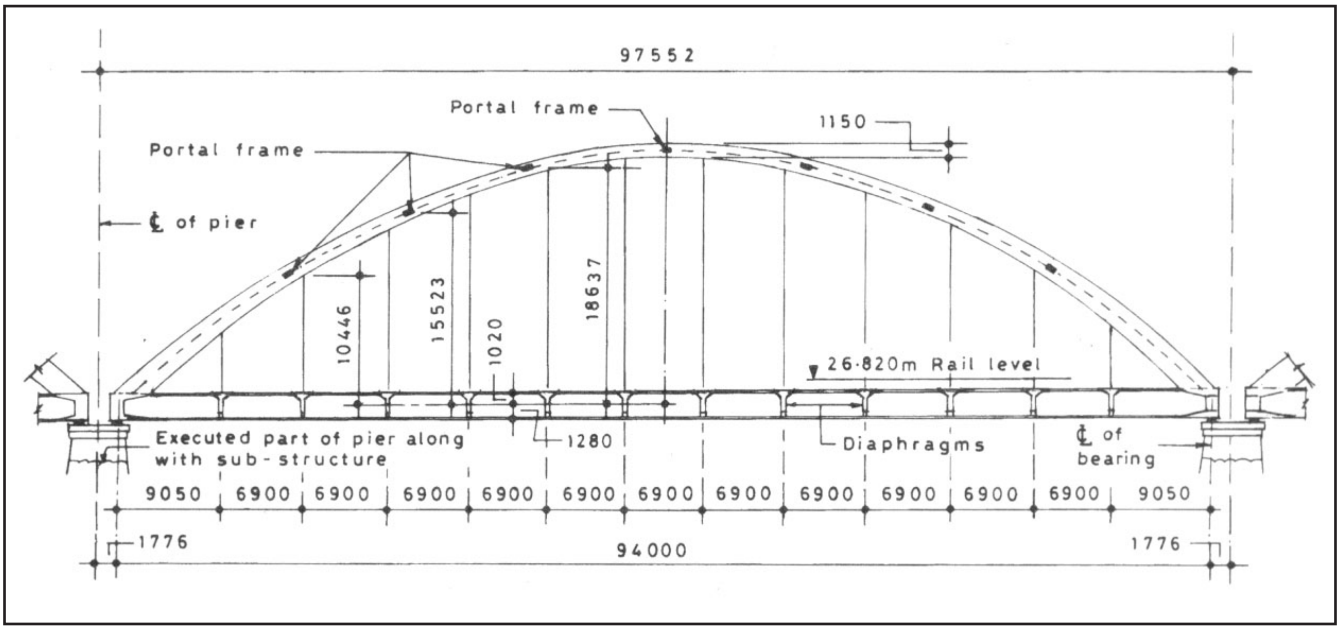

Figure 3. Longitudinal section of a typical bow-string arch superstructure

Railway's design whereas for concrete design, the firms were free to propose their own design. From the offers received, in case of steel girder option, the value of the work for superstructure construction including the value of special conditions, varied from Rs 31.36 crores to Rs 34.75 crores.

In case of concrete option, the offer of Hindustan Construction Company Limited (HCC) was not only lower but also the lowest of all offers received at a value of Rs 19.96 crores. The other concrete offer was given by Larsen and Toubro Limited, Madras. This proved that concrete superstructure was economical compared to its steel counterpart.

The design offered by HCC, Bombay consisted of bowstring type concrete arch of span 92.552m (clear) with a prestressed concrete box girders to act as the tie. L&T, Madras, proposed prestressed concrete trusses, one on either side, connected to each other by cross members. Since railways were attempting the adoption of such a large span using prestressed concrete construction for the first time, it was decided to seek the guidance of an expert in the field to help the railways in choosing a suitable design. Accordingly Leonhardt Andrae & Partners of Stuttgart, West Germany were appointed as proof consultants to evaluate both the concrete designs received.

The consultant found both the designs sound. Bow string arch structure design offered by HCC is an elegant structure and also incidentally is lowest offer. Though its erection is not easy, the design is more durable as the number of joints are kept low and continuity at the joints is possible by having longitudinal reinforcement continuous over the joints. Also, inspection and maintenance are simple for the arch solution with closed box girder. Considering the various aspects, the proof consultants gave a recommendation in favour of the bow string arch structure.

Bow-string arch girder

Based on technical suitability as well as financial considerations, it was decided to go in for bow-string arch girder. The 94-m arch (centre to centre of bearings) rises 20m above the level of the centre of gravity of box tie-girder, Figure 3. While the width of the arch is constant at 800 mm, its depth varies parabolically from 1,150 mm at mid span to 1,700 mm at the junction where the arch meets the tie-girder. The deck is supported from the arch by means of 12 pairs of hangers enclosed in HDPE ducts to protect them. While the arch is of reinforced concrete of M45 grade, the prestressed concrete tie-girder is of M42 grade. The prestressing system used for the permanent stressing of girder as well as temporary prestressing during construction is BBRV system that uses button heading.

Each girder is supported on pot bearings of 1050-t capacity. While three sets of bearings have been imported from Proceq of Switzerland, the remaining bearings have been manufactured at the factory of BBR(I) Ltd., who have specially developed facilities for this purpose at their Bangalore factory with technical collaboration from Proceq of Switzerland, BBR(I) Ltd, Bangalore, have also developed facilities for the assembly of hangers. The hangers are then transported to the site of work by road. Stringent quality control measures are adopted while accepting the raw materials used for the manufacture of bearings and hangers, in the manufacturing process and in the acceptance of final product. Various prestressing operations both temporary as well as permanent are also being carried out by BBR(I) Ltd., under licence from BBR Ltd., Zurich, Switzerland.

Construction method

The method used for construction is the cantilever method of construction. The arch is built in segments starting from a pier and proceeding symmetrically on either side. The segments are supported during construction by running cables from a 30-m tall temporary tower erected over each pier. When two half arches are thus completed, there is a gap of 1.5m between them. When this gap called the closing pour is completed, the arch gets completed. The tie-girder is also constructed in segments over tie-girder scaffolding supported from the arch by means of the same hangers, which are used to suspend the girder at a later stage.

Since the structure being built is a three dimensional space structure, controlling of various stages is very important. Accurate survey instruments are used to monitor the shape of the arch and the camber of the tie-girder at each stage. Detailed drawings and tables have been supplied by BBR Ltd., Switzerland, consultants to the contractors. These were used to control the forces in the cables holding the arch, the longitudinal prestressing cables in the tie-girder and the hangers during the construction.

Load test

As per the Railway's specifications, one completed span need to be load tested as per the provisions of IRS concrete bridge code. As per this code, the span should be loaded with 1.25 times live load which should be maintained on the span for a period of 24 hours. The recovery of deflection on removal of the live load should at least be 85 percent. The load test was conducted between January 17 to 20, 1995 proved adequately the capacity of the structure to carry the design load.

Factors responsible for delay

For this bridge, innovative design and construction methods have been adopted. Initial teething problems had to be sorted out, both in the field of design and construction. Moreover, the contractor, Hindustan Construction Co. Ltd., faced acute financial constraints during 1992-93, which slowed down the progress. Also, in 1993, there was labour unrest/strike, which delayed the progress further. Railways had granted an adhoc advance to the contractor on his request in September 1993, to enable him to overcome the financial constraints and expedite the progress. Since then, the work has picked up momentum and continues to be so at present. Approximately 70 percent of the superstructure has been completed already and the bridge is targeted to be completed in May 1996.

Conclusion

Various aspects connected with the construction of the bridge such as design features, construction features of substructure, construction features of superstructure, quality control measures, procedures for load testing etc., are covered in detail in the articles that follow. An overview of the construction of the bridge from its inception stage has been attempted in this article. When completed in May 1996, the structure is expected to be another engineering marvel, an efficient bridge carrying modern track structure permitting unrestricted speeds.

South Central Railway has achieved a great feat by constructing a longest prestressed concrete bridge on the railways, for the first time in India. The bridge work has been taken up as a challenge absorbing the technology, and successfully implemented and proved by testing the span that the work can be executed with ease. This will give a long felt impetus to the engineers to introduce more and more novel designs in bridge construction which will give trouble free service.

G.V. Ratnam, Chief Engineer, South Central Railway, Headquarters, Secunderabad 500 371

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