First externally prestressed concrete bridge in India at Sringeri

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A 142-m long pedestrian bridge at Sringeri Joining the famous holy temple complex on the northern bank with the math complex on southern bank has recently been constructed to facilitate uninterrupted movement of the pilgrims. The unique feature of this prestressed concrete bridge is its slenderness and the provision of the prestressing cables in the inside hollow portion of the deck. This is probably the first time in India that a bridge is constructed with prestressing cables provided externally.

Holy river Tunga, which is a north-bound river (uttaravahini) upto Sringeri, takes a turn to flow as east-bound (purvavahini) river. It skirts the Narasimhavana complex that houses the abode of the holy Shankaracharyas - the descendants of the great Hindu saint, Adi Shankaracharya of 8th century A.D.- on the southern bank, separating the holy temple complex of Shree Sharada and Vidyashankar at the northern bank.

There was an urgent need for a bridge joining the temple complex on the south bank with the math complex of Narasimavana on the north bank; as the pilgrims travel day and night to attend the various ceremonies conducted at both the shrines. The river, having taken a sharpturn at the southern bank, shows turbulance and eddies, and more so in the monsoon. The crossing by boats, becomes extremely risky and dangerous. Many lives have been lost during the past. Therefore, His Holiness, the late Abhinava Vidya Tirtha, Swamiji , popularly known as Mahasannidhanam, decided to build a permanent bridge across the river so that the pilgrims can attend to all the ceremonies without difficulties. Figure 1 shows a view of the temporary crossing which was used prior to the construction of new bridge.

Location

The location of the bridge was an important aspect. A new bridge at the location of the existing temporary bridge would have led to a longer and costlier proposal. It was also too risky to locate it there, as it was just at the turning point of the river. The new bridge is therefore located just at the downstream of bathing ghat, as it is the shortest possible route, and on a fairly straight in reach, with crucial foundation protected by the ghat section. The exposed rock met at this bank indicated that good rocky strata would be met at a fairly shallow depth at other foundation locations as well. This was proved correct.

General arrangement

After considerable discussion and considering the various alternative proposals of different types of bridge decks and span arrangements, a continuous bridge of 110m length across the river with 24.5-m long curved approach viaduct leading to a 7.5m masonry ramp on the Narasimavana bank was finalised. The Narasimavana bank has a plenty of plantations. In order not to destroy the same, a cured viaduct was found to be the only feasible and sound proposal.

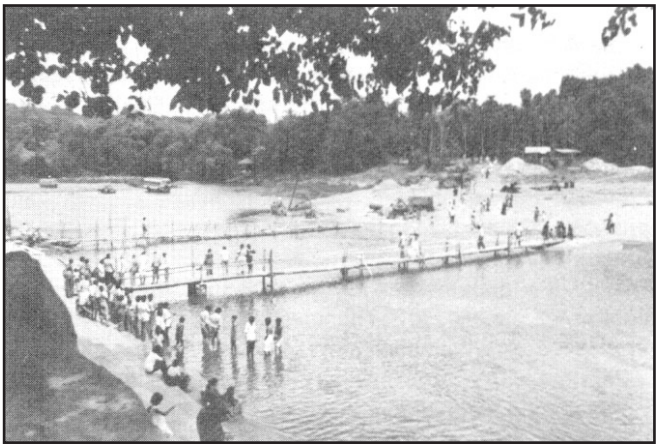

Figure 1. Temporary crossing at Sringeri prior to the construction of the bridge

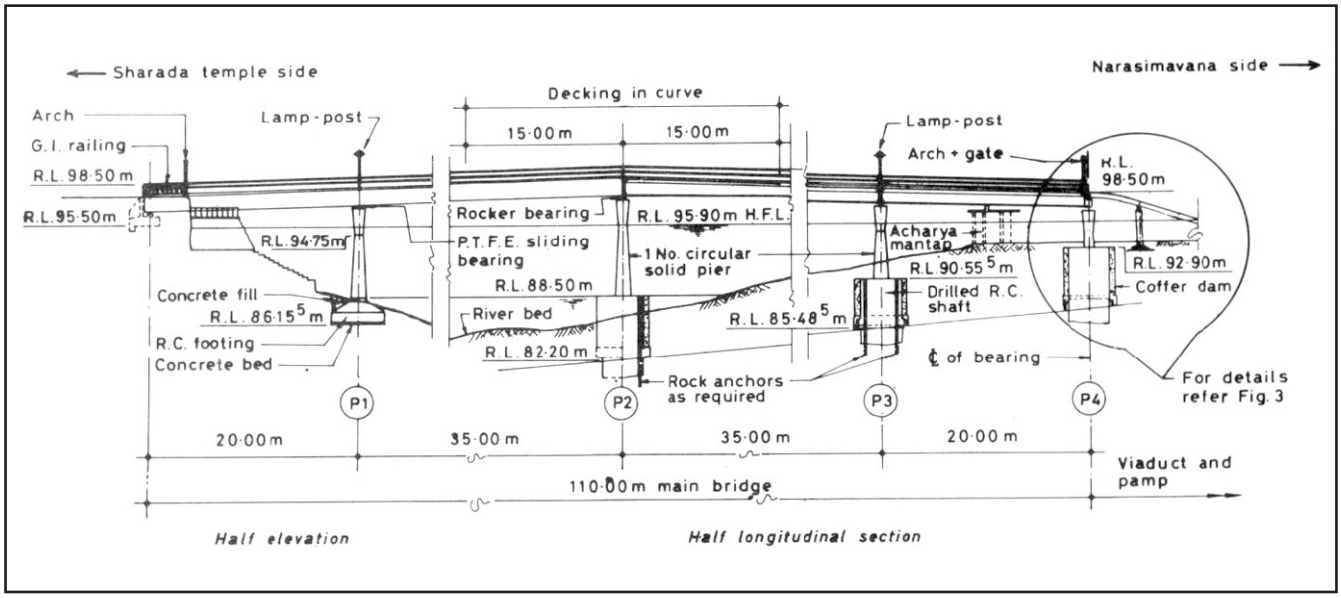

Figure 2. (a) Elevation of the main bridge

The viaduct has been provided with curved deck in 'S' shape with an angle of curvature of 53° for the river side span of 7.25m and 19.5° for the abutment side span of 7,1 m to provide a smooth transition from the bridge to the Narasimavana pathway. The curvatures of the approach were dictated by the existing pathway and the surrounding plantation. Thus, the total length of the crossing works out to 142m connecting the holy shrines on both the banks.

As the bridge is located in the private property of the Sringeri math, the authorities wanted only a pedestrian bridge without provision for vehicular traffic. A 2.5m clear footway width was decided for the bridge deck. The main bridge across the river consists of 4 spans of continuous deck with two end spans of 20m each and intermediate spans of 35m each, providing 110m between the centres of bearings, Figures 2(a) and 2(b). The viaduct portion consists of three continuous spans, with span arrangement of 7.25m - 9.56 m- 7.10m between the centres of bearing, Figure 3. The span of 7.25m and 7.10m are in the curved zone with minimum radius of curvature of 7.5m for 7.25m span. The 7.25m span is made to rest on the articulated portion of the main bridge deck.

Superstructure

The superstructure for the main bridge consists of a single cellular box of uniform depth of 1.5m having a trapezoidal section with 1.15m width at the soffit widening approximately to 1.8m at top, supporting 2.8m overall deck width. The viaduct portion of the deck slab is in solid section of 0.45m depth with a matching haunch configuration. it provides for 1.7m width at the soffit. While the main bridge has been designed as a prestressed concrete box, the viaduct portion is in reinforced concrete.

Substructure

On account of the possible skewness of flow and with a view to improve the aesthetic of the slender bridge deck, the

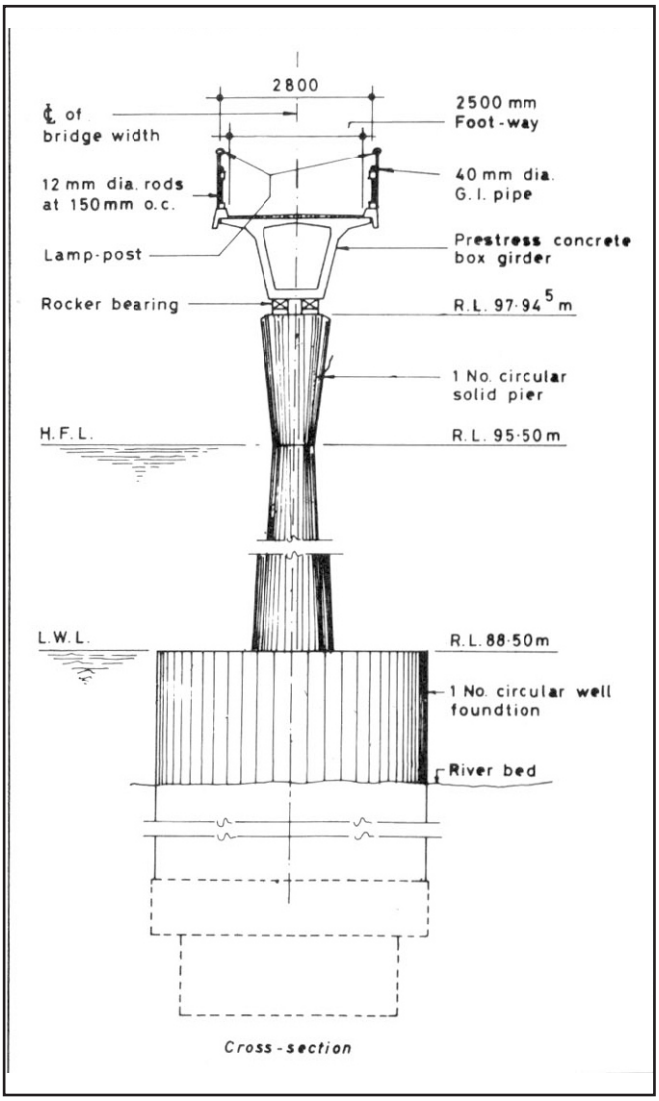

Figure 2. (b) Cross section of the main bridge

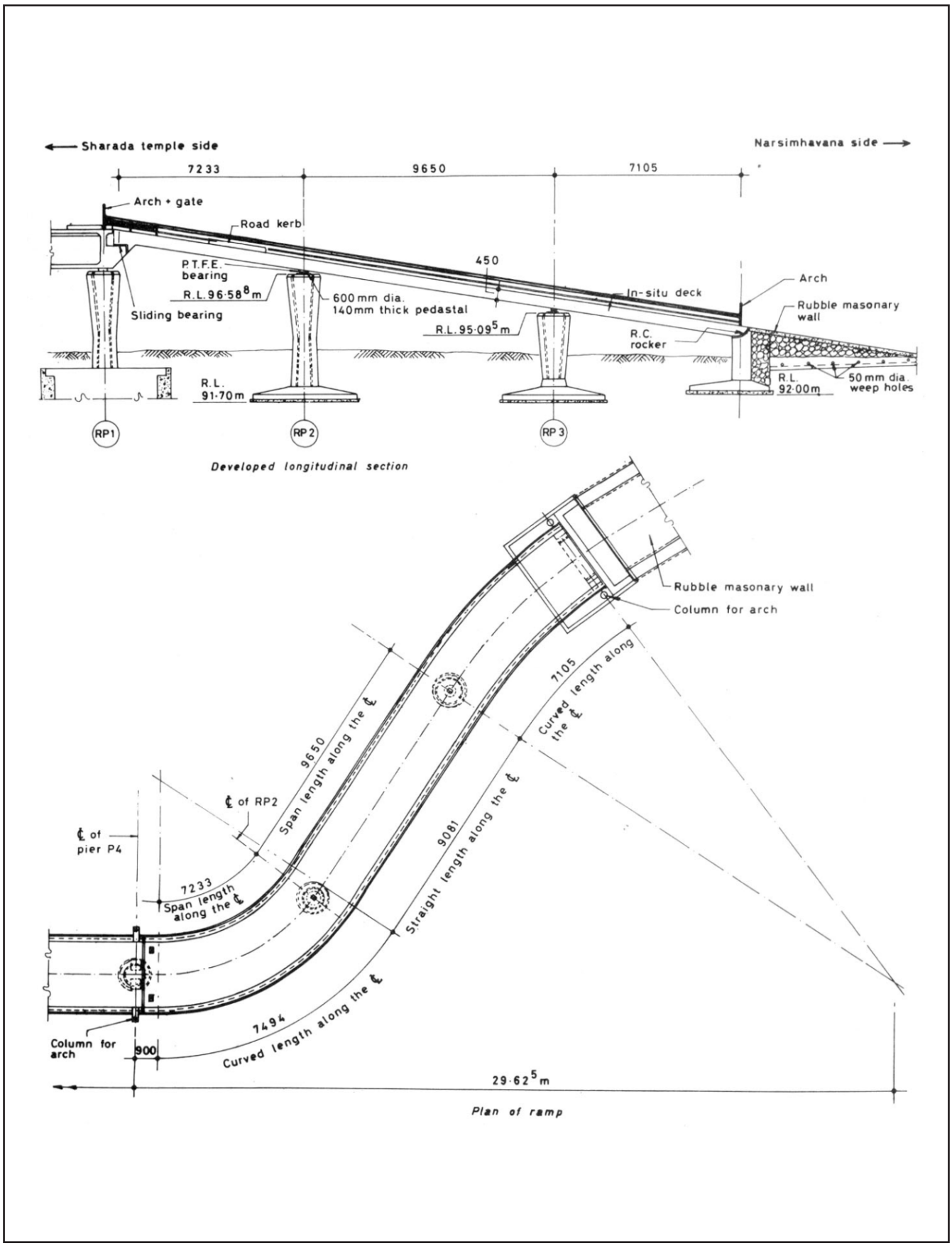

Figure 3. Longitidinal section and plan of the viaduct portion

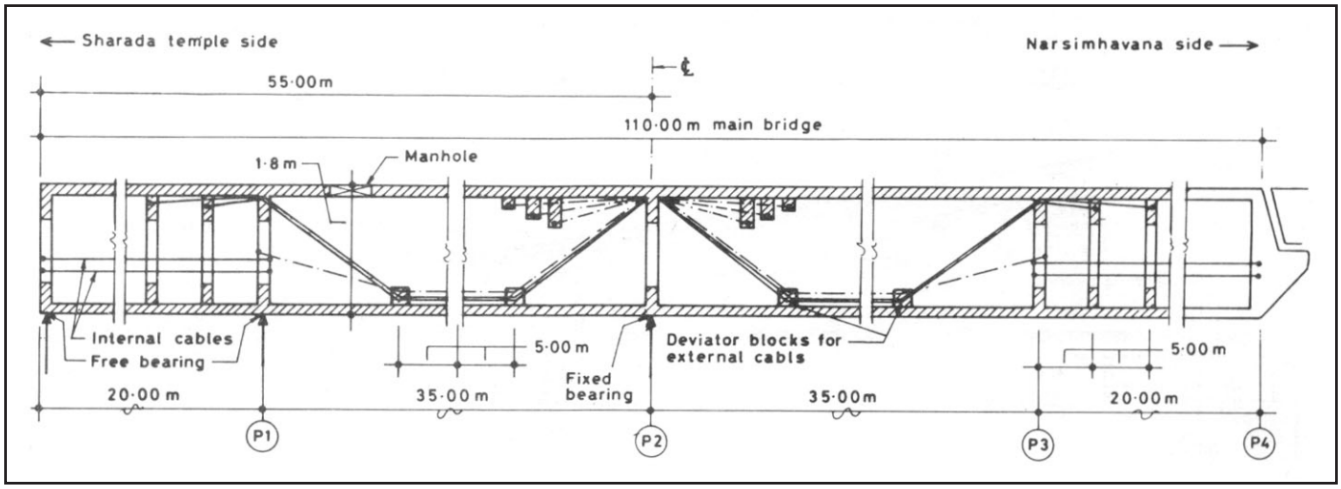

Figure 4. Sketch showing typical arrangement of external cables

supporting piers are kept slender and possess solid circular section. They are tapering with the least dimension of 0.9m at the flood level widening to 1.5m at the base of tallest pier and again widening to the top to 1.3m to support the bearings. The piers have been extended into the rock in the river portion, to provide a firm grip, necessary on account of the slender and tall height of the piers for an otherwise light bridge.

The exposed rock with an overlay of sandy bed demanded the provision of concrete coffer dams to be sunk and anchored into the rock. This enabled dewatering that helped in drilling and anchoring the pier shaft into the hard granite rock below. The central foundation P-2 had the rock strata steeply dipping with an overlay of a softer rock, which gave way during the process of shaft sinking, under the dewatered condition on account of the external hydrostatic pressure. This necessitated lowering down of steel liners in two parts with an overlapping joint from inside the cofferdam, sealing the annular space and then completing the work under dewatered condition. This foundation has been provided with 4 Nos of 4x12.7mm diameter stranded cables, ground anchored as a measure of additional safety. As the main and approach bridges are of continuous type, the other open foundations, which are resting in the soil have been provided with timber piles driven to refusal to ensure non-yielding supports underneath.

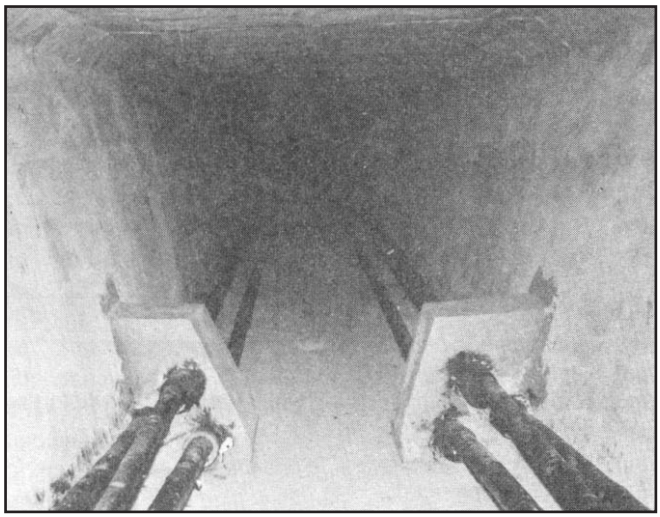

Figure 5. A view of the external prestressing cables with deviation block

Bearings

The central pier P-2 has been provided with rocker bearings with other supports acting as free supports permitting only the longitudinal movement for catering to the temperature, creep and shrinkage effects. To match with the aesthetics, the piers for viaduct spans have also been kept identical. The bearings for the viaduct portion are specially-made pot-type bearings, which permit both longitudinal and transverse movements within certain limits.

The end support of the viaduct at ramp location has been in the form of curved rocker bearing provided in reinforced concrete. Since this area is susceptible to submergence during the high floods, metallic bearings were not considered suitable on account of probable rusting and other maintenance problems. Incidentally, this continuous rocker also acts and provides a fixed support to prevent excessive transverse movement of the curved viaduct on account of the very rigidity of the bridge deck in the transverse plane. The free bearings of the main bridge as also the pot bearings of the viaduct are of PTFE type.

External prestressing

The unique feature of this bridge is its slenderness and also the use of the external cables for prestressing. This may perhaps be the only bridge of its kind to be built in India where prestressing cables have been provided externally. The proposal for the use of external cables was preferred as the cables could be inspected and replaced with ease. The external cables have been so far tried in India to strengthen weak structures or repair them, and as permanent cables in actual construction.

The cable consists of a combination of 4 Nos of 12mm diameter and 7 Nos of 12.7mm diameter strands, stressed individually. Figure 4 shows general arrangement of external cables. The formation of cables and stressing of cables required extreme care. In fact, casting the deviation blocks to suit the design

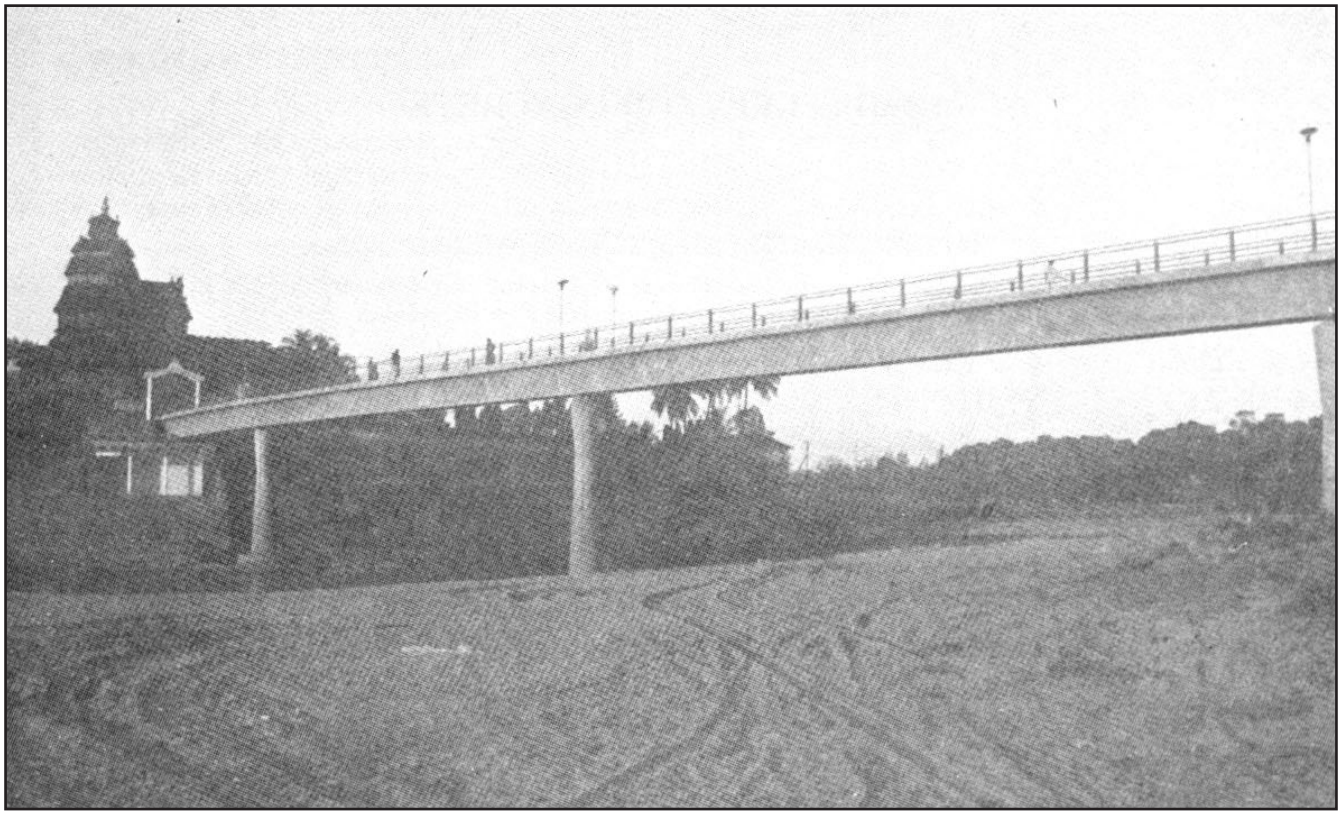

Figure 6. A part view of the completed bridge

requirements was extremely laborious task, requiring checking of the angle in 3 different planes. Keeping in view the constraints of operating in a shallow box, larger diameter ducts were provided. Further, in order to provide a smooth movement, the sheathing ducts were placed inside a lead sheet introduced in the aligned G.I. pipes embedded in the end blocks. As the cables had to be stressed individually, to ensure their correct alignment all throughout, colour code was adopted and the cables were threaded through wooden templates located at intervals.

The sheathing pipes with couplers were kept loose in between the deviation blocks for joining, once the cable is stressed. To prevent ingress of water at a later date, the sheathing ducts were sealed with a special type of craft paper from outside and painted with bitumen, subsequent to grouting with neat cement grout. The end anchorages were similarly sealed in a steel box, fastened to the concrete and epoxy sealed after grouting. Figure 5 shows a view of the external cables with deviation block.

The bridge deck has been provided with suitable drainage systems and also manholes for inspection of the deck from inside. With a view to keep the temperature effects under control, ventilation holes at regular intervals have been left not only in the soffit slab but also in the webs and end diaphragms. The railing is of continuous G.I. pipe supported from the structural steel channel frames filled in with vertical reinforcing rods to ensure safety of the pedestrians. The deck provides lamp posts for lighting the bridge at night.

To ensure solitude to their Holinesses during the 'chatturmas' - generally the four monsoon months - and also at other times as and when required, a gate has been provided between the main bridge and the viaduct so that movement of the pilgrims could be restricted. The entrance to the bridge is provided with arches with decorative motif keeping in with the surrounding monuments befitting the holy place. Figure 6 shows a part view of the completed bridge.

This pedestrian crossing fulfills one of the cherished desires of His Holiness the late Mahasannidhanam of haloed memory, who unfortunately took samadhi, before the bridge could be completed.

Acknowlegement

The author wishes to record that this bridge could not have seen the light of the day, had it not been for the active participation, guidance and encouragement received from His Holiness the late Mahasannidhanam Abhinava Vidya Tirtha Swamiji of haloed memory, in whose name the bridge has been dedicated by the present pontiff, His Holiness Bharati Tirtha Swamiji.

The author also wishes to express his gratitude to the management of Gammon India Limited for the encouragement given by them for writing this paper.

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(Source: ICJ July 1991, Vol. 65, No. 7, pp. 331-335)