Railway bridges across Sharavathy and Kali rivers

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The article highlights broad construction features of two major bridges on Sharavathy and Kali rivers in the Uttar Kannada district of Karnataka. While the Sharavathy bridge is 2.06-km long, the Kali Nadi bridge is 1.4 km long. It is probably for the first time in India that such long bridges across major esturian rivers are being completed in a short period of just 30 months. The credit for this achievement goes mainly to the adoption of pile foundations and use of extensive precasting.

Konkan Railway presents some daunting engineering challenges to the railway engineers in the form of long bridges and tunnels. The longest bridge on the line is about 2.06-km long across the Sharavathy river near Honnavar in Uttara Kannada district of Karnataka. This bridge consists of 55 spans of 33m and 11 spans of 22.8m. The second longest bridge on the line is about 1.4-km long and is located across the Kali river near Karwar in the same district. This bridge is configured as 42 spans of 33m. Figures 1 and 2 show the longitudinal and cross sections of these bridges.

Survey

A precision triangulation survey was done using 1" theodolites and electronic distance meters connecting survey platforms in the river. The coordinates of the survey points were then computed. Once these coordinates were known the coordinates of any point on or off the alignment could be determined and set out.

Choice of foundations

Trial bores taken at various locations along the alignment indicated that sub strata consisted of coarse sand or laterite overlying fine clay over weathered rock. Hard rock is available at depths ranging from 19m to 30m below bed level. In the Sharavathy river sub strata consists of layers of coarse sand overlying fine sand/soft to fine marine clay over weathered rock. Both the rivers fall in the tidal zones and as they are not prone to floods, there is less likelihood of deep scours. Measurements of scour at Kali Nadi bridge site indicated depression of river bed to the extent of only 150mm to 200mm at pier locations. The maximum depth of standing water is about 7m at Sharavathy and 6.5m at Kali Nadi. The options for foundations were :

1. well foundations, and
2. pile foundations.

Strata conditions at both the bridge sites presented hard granite rock at depths of 20 m to 30 m below bed level. Therefore, adoption of end-bearing bored and cast-in-situ piles proved to be an economic alternative for foundations. This also helped in reducing the period of construction.

Each pier was founded on four piles. The abutments are of spill-through type and are resting on six piles.

All the piles are designed as end bearing piles and are socketed in hard rock. The depth of pile ranges from 15m to 40m. The number of piles involved are 288 for the Sharavathy bridge and 180 for Kali Nadi bridge.

Pile foundations

Pile boring

The work of piling is done from made-up, earth-filled islands at locations where the water depth is less. With greater depths of water, platforms are made by driving temporary liners into the river bed. Floating pontoons to carry the rigs and other equipment and which could be suitably anchored for working are used at the Kali Nadi site. Upto six piling rigs worked at each site and around 20-25 piles could be bored per month.

For ensuring quality and durability of the piles, it was proposed that the piles be lined for the entire depth with

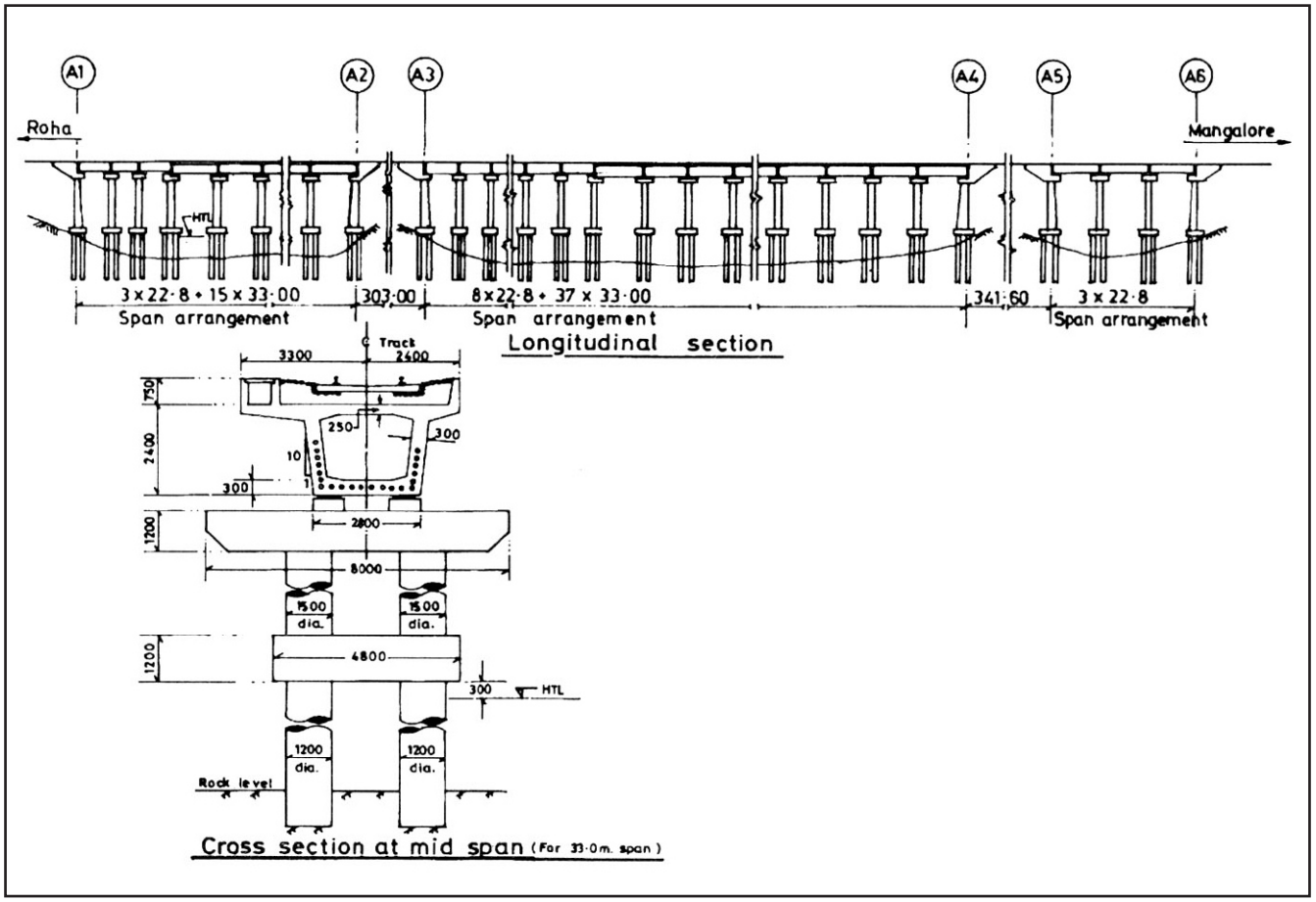

Figure 1. Longitudinal and cross sections of the bridge across river Sharavathy

6/7mm mild steel plate liners. During execution, however, except for a few piles the rest could not be lined fully. Generally, only the top 15-20m could be lined before excessive skin resistance or obstructions like wooden logs caused refusal of the driving process. Driving of liners was done by using winch and drop hammer / bailer, or by a vibrohammer as in the case of Sharavathy bridge. The vibrohammer can drive or extract liners, achieving a penetration of 15cm in less than five minutes. The top of the liner has to be suitably strengthened for driving by either method.

Two methods were used for the pile boring : bailer / chisel method and the direct mud circulation (DMC) method. In the bailer and chisel method, the strata is first chiselled by repeatedly dropping a heavy winch-operated chisel. In case the strata is soft, the bailer can be directly applied. In the DMC method, a series of hollow DMC pipes are attached to a chisel which is repeatedly worked up and dropped by a winch. Bentonite solution is continuously circulated through the DMC pipes and it carries away the pulverised materials to the top and the same overflows the pile liner. A record of the strata encountered was noted and recorded by monitoring the samples as the bore progressed.

Pile concreting

After lowering the reinforcement cage, pile concreting is done by the tremie method as given in IS-2911. Concrete srade of M25 was used with a cement content of 415-425 kg/m^3. Watercement ratio of 0.48-0.50 was used to ensure proper slump. Mean strength of works cubes was in the range of 32-40 N / mm^2 with a standard deviation of 5-6 N / mm^2.

Substructure

A group of four to eight piles was capped by a 1.2m-thick pile cap. Two 1.5-diameter trestle columns rest on the pile cap. A bed block 1.2-m thick tops the columns. Pedestals are cast on the bed block to provide girder seating.

Superstructure

PSC box girder of 33-m span

An optimised design was evolved for the precast post tensioned PSC box girder having 33m overall span. Two stage stressing of the high tensile steel is contemplated. First stage of stressing is applied while the girder is on the casting bed and the 2nd stage of stressing is carried out in the stacking yard after laying the wearing coat. Diaphragms are cast subsequently. Precast kerbs are also attached to the girder by means of bolts in the stacking yard. This reduces the in-situ works to be done after launching which involves casting of end cantilevers only, thus saving time and ensuring quality.

Each girder requires around 135 m^3 of M40 grade concrete, 16 tonnes of high yield strength deformed bars and 6.5 tonnes of

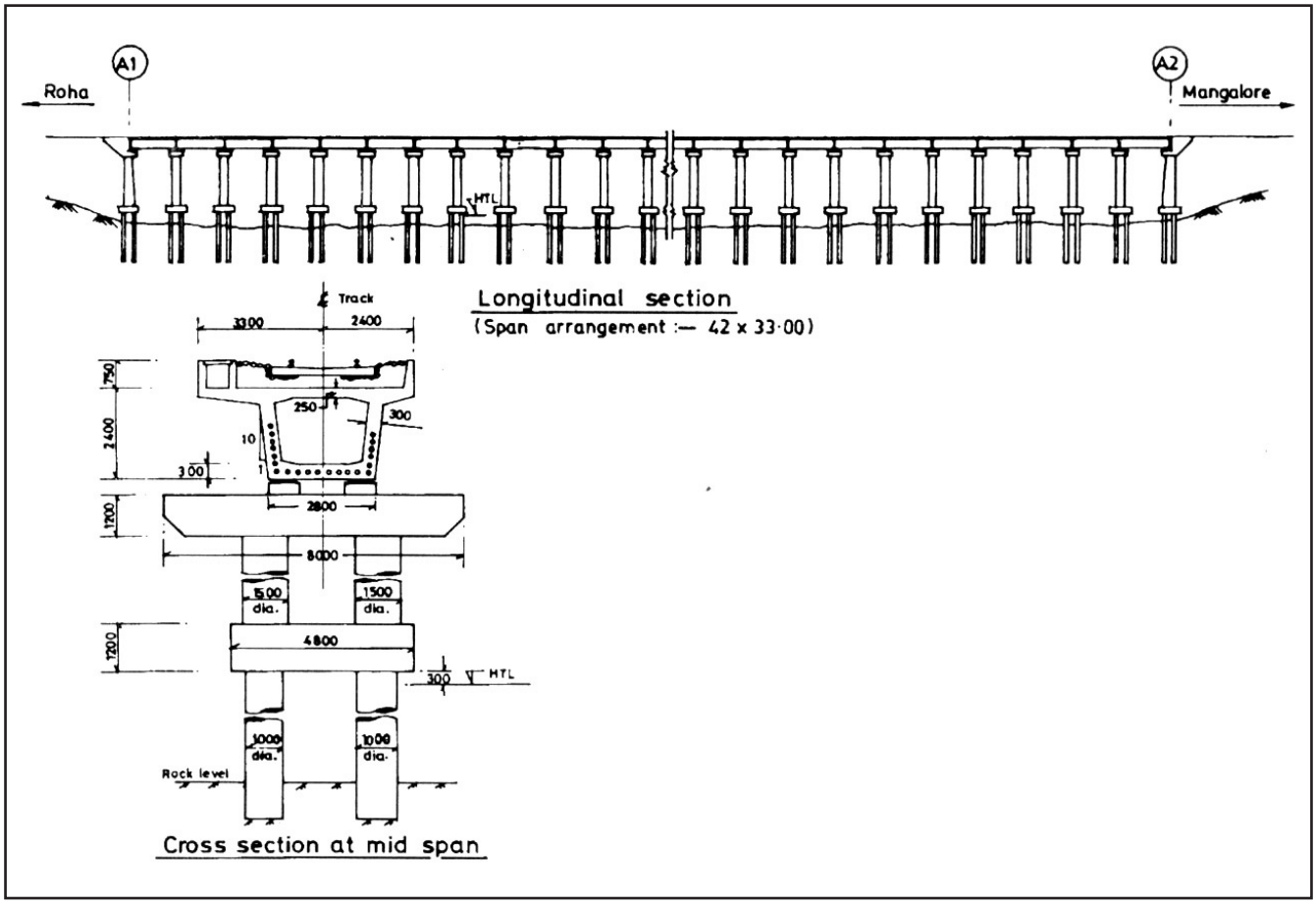

Figure 2. Longitudinal and cross sections of the bridge across river Kali Nadi

high tensile steel. In view of the severe environmental exposure conditions, single pour concreting is done, without cold joints. This gave rise to complications of shuttering which were solved using collapsible shutter trains which could be pulled out as a unit. Figure 3 shows a view of the casting bed at the Sharavathy bridge site.

At Sharavathy bridge site, a batching plant of 30m^3/hr capacity coupled with a pump completes the girder concreting in a single pour in 10-12 hours. The system at Kali Nadi uses a tower crane and bucket placer with a batching plant of 7m^3/hr capacity, which is capable of completing the concreting work in 18-20 hours.

The mix for M40 grade concrete uses 450 kg /m^3 of cement content with a water-cement ratio of 0.38. Superplasticiser-cum-retarders are used to maintain high slump and prevent cold joints. Quality control measures include testing of aggregates, water, cement, green concrete, hardened concrete, an-ticorrosive treatment including permeability testing of concrete.

Stressing

For each girder, 21 numbers 12T13 cables are used. The stressing system differs for the two bridges. At Sharavathy site the Tensacciaci (Italian) system is used.

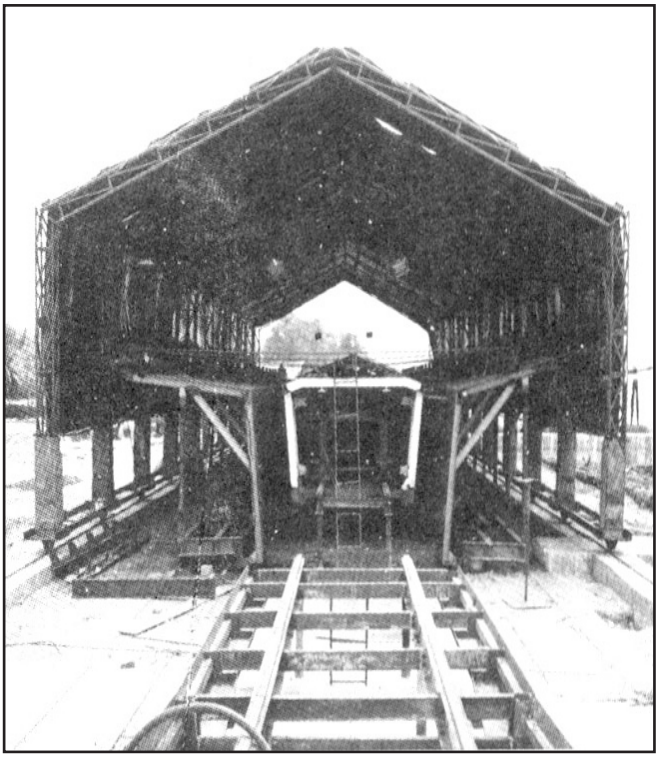

Figure 3. A view of the casting bed at the Sharavathy bridge site

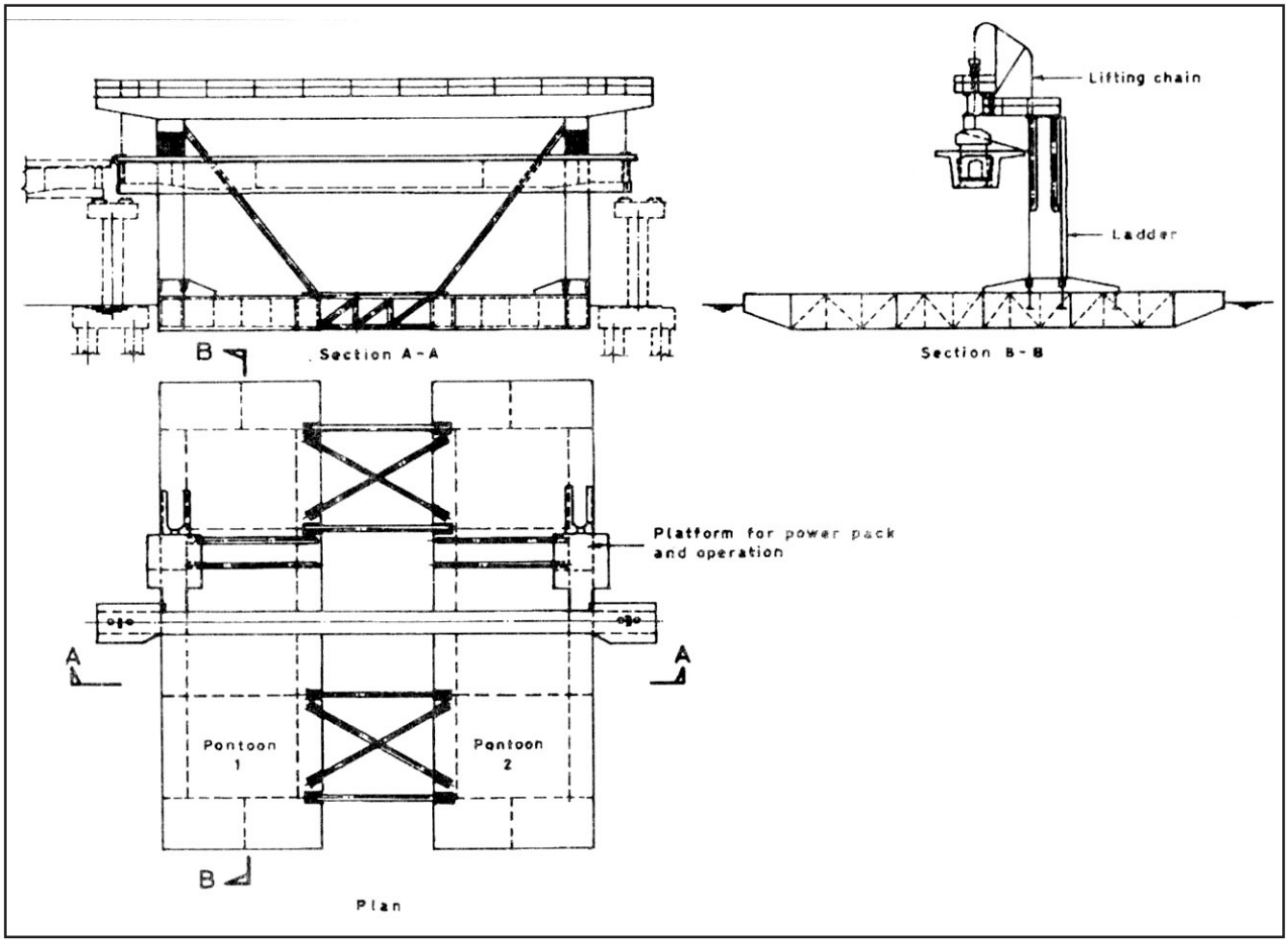

Figure 4. Launching of box girder using a floating crane

The anchorage is made up of curved plate which distributes the anchorage forces on the concrete. Freyssinet system is used at the Kali Nadi site.

Anti-corrosive treatment

All mild steel and/or high yield strength deformed bars used in the PSC work are trea ted by the method patented by Central Electro-chemical Research Institute (CECRI), Kara ikudi. This involves derusting the bars by acid pickling, applying coats of phosphating jelly followed by a cement based inhibitor and finally the pores are sealed by using a patented sealer. For the high tensile steel, all care is taken to retain the protective oil film as received from the factory. Immediately on concreting the ducts are filled up by putting oil-water mixture. Grouting is done within 3-4 days of stressing. The end anchorages are then painted with two layers of epoxy paint.

Casting 20 -m spans

Precast pretensioned 'T' section girders (3 Nos. per span) are used for the 20-m spans. These individual girders are connected by cast-in-situ diaphragms and also cast-in-situ portion between the flanges of adjacent 'T' beams. The grade of concrete is M45 and steam curing is adopted to expedite the casting.

Launching of girders

To maintain quality and uniformity for the girder concrete, PSC girders were precast in casting yards and then launched into position on the span. Selection of launching scheme depends on the infrastructure available with the contractor, site conditions and is different for the two sites.

Launching at Sharavathy site

A special barge weighing 350 tonnes was fabricated at the site, with two towers to keep the girder suspended. As the depth of water at certain locations was shallow, one dredger was also fabricated at site. The barge is thoroughly tested by non-destructive tests as the entire weight of the PSC girder (400t) is borne by it.

The girders are lifted from the launching jetty on to the barge where they are held in suspended condition. The barge is then towed into position using tugs on the river and the girder is lowered onto the bearing pedestals, Figure 4. Five box girders are being launched per month by this method. The scheme has the advantage that a girder can be launched on any two adjacent piers once they are completed. Figure 4 shows the launching arrangement for the bridge.

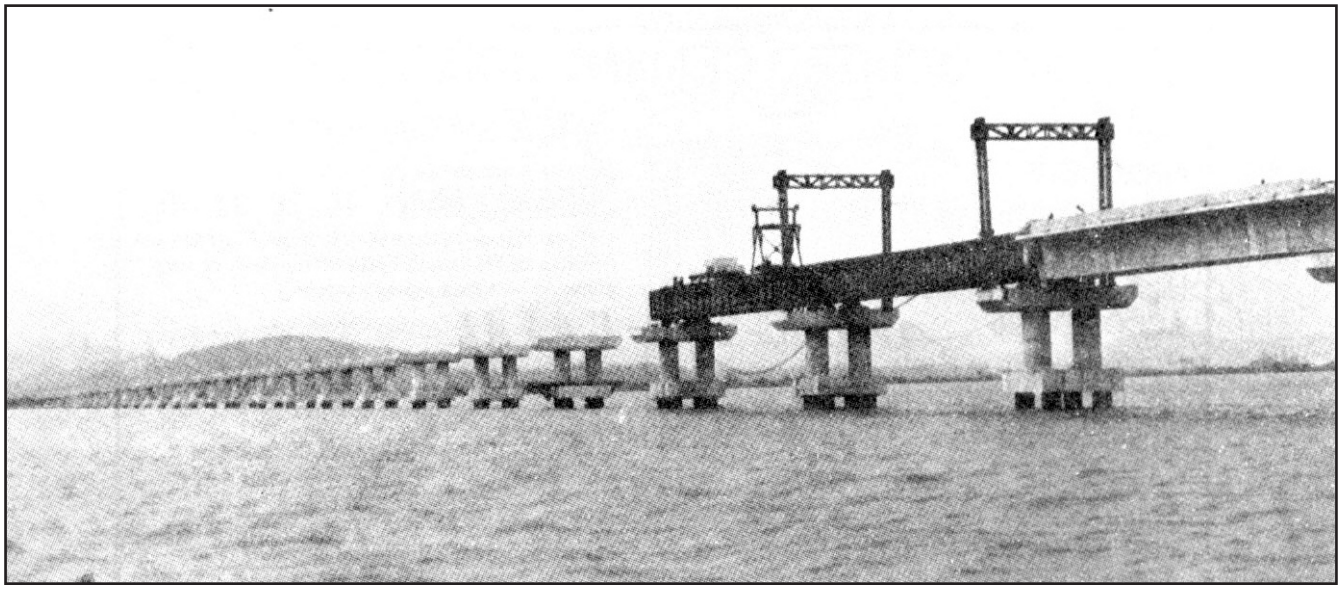

Figure 5. A view during superstructure launching for the Kali Nadi bridge

Launching at Kali Nadi site

At Kali Nadi site, a two and a quarter span long plate girder weighing 100 tonnes is used for launching. The launching is done from one end progressively. The PSC girder is placed on track-mounted trolleys and brought on to the launching girder, which is temporarily positioned across the span to be launched. The PSC girder is then lifted up on concrete brackets (cast integrally with the girder) using jacks operating within a portal frame arrangement. The trolleys are then moved out and the launching girder is pulled ahead by one span leaving the span, under the raised PSC girder, clear. The PSC girder is then lowered in stages onto the bearings. Track is then linked to the launched PSC girder and the process is continued for the subsequent spans. Figure 5 shows a view during the launching operation.

Current progress

In a period of just over two years, complete substructure at both bridges has been completed. Presently, the work of girder casting and launching is in full swing. At Sharavathy 46 numbers of 33 m long box girders have been cast and 36 launched, and 14 numbers of 20 m span girders have been cast on date. At Kali Nadi site, 24 girders have been cast and 21 launched. The entire work on these two bridges is expected to be completed by April 1994.

Cost

The total estimated costs of Sharavathy and Kali Nadi bridges are Rs 20.67 crores and 13.90 crores, respectively.

Conclusion

By adopting pile foundations and precast PSC girders it has been possible to complete 80 percent of the work on these bridges in a span of about 24 months. Both works are expected to be completed in just 30 months.

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