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Innovative Construction and Design of Three Marine Bridges

Conception et construction innovatrices de trois ponts martimes

Innovative Errichtung dreier Seebrücken

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SUMMARY
This paper describes the innovative techniques developed for three marine bridge projects to suit the site constraints and infrastructure available. Launching of superstructure girders using tidal variations, use of concrete-steel cofferdam assembly in marine conditions and use of precast segmental construction with centralised casting yard are covered.

RÉSUMÉ
L'article décrit les techniques innovatrices mises au point pour trois projets de pont maritime, devant satisfaire aux exigences de la situation des lieux et de l'infrastructure existante. Il s'agit du lancement des poutres de tablier par utilisation de la variation d'amplitude des marées, l'exécution de batardeau en béton armé en milieu marin et, enfin, la préfabrication de voussoirs centralisée sur un unique chantier de bétonnage.

ZUSAMMENFASSUNG
Der Aufsatz beschreibt die Bauverfahren, die für drei Seebrücken entsprechend der Lage der Baustelle und der verfügbaren Infrastruktur entwickelt wurden. Sie umfassen das Einschwimmen des Brückenüberbaus unter Ausnutzung des Tidenhubs, den Bau eines Kofferdamms aus Beton und Stahl unter maritimen Bedingungen und die Verwendung der Segmentbauweise von einem zentral gelegenen Fertigteilwerk aus.

1. INTRODUCTION

Bridges form a very interesting class of structures and often involve difficult working conditions. For large bridge projects, the choice of the right type of construction technique is very important. Construction techniques have to be evolved suitably fully keeping in mind the site constraints, the infrastructure facilities available and the design requirements. For major bridges an integrated approach coupling design and construction schemes is vital. Again, marine crossings pose more severe challenges and require greater construction skills. Under Indian conditions where sophisticated construction machinery are not generally available and labour is inexpensive and relatively less trained in mechanised construction, innovative approaches have to be evolved to formulate simple and foolproof solutions which also have to be cost efficient in view of the competitive 'Design & Construct' tendering process of awarding bridge projects. In this paper Appropriate Technology in construction and design techniques adopted for three marine bridges is presented.

2. SUPERSTRUCTURE FOR VASAI CREEK RAILWAY BRIDGES

2.1 Description

The two railway bridges across Vasai Creek having 39 and 11 spans respectively are spread over 3 km length, separated by an island. The bridges have two independent decks, each carrying one broad gauge track. Each 48.5 m simply-supported span deck has a single-cell prestressed concrete box girder of 3.3 m uniform depth . Each girder weighed 500 t as cast and 750 t during launching including kerbs and ballast loading. To achieve good quality control all the 78 girders were precast on the shore and launched into position.

2.2 Launching Technique

The creek has a tidal variation of 4.5 m range and this was taken advantage of to evolve an inexpensive and innovative scheme of launching the heavy girders using tidal variations, probably for the first time in India. After precasting, prestressing, grouting and carrying out various finishing activities such as kerbs, waterproofing, wearing coat and partial ballast in the casting yard itself the girder is moved on to a launching jetty. A launching pontoon with a spreader truss on top is brought below the girder at low tide. With rising tide the pontoon rises up and lifts the girder off the jetty. It is then towed to the bridge site using tugs and positioned in location at high tide. As the tide goes down the girder is progressively

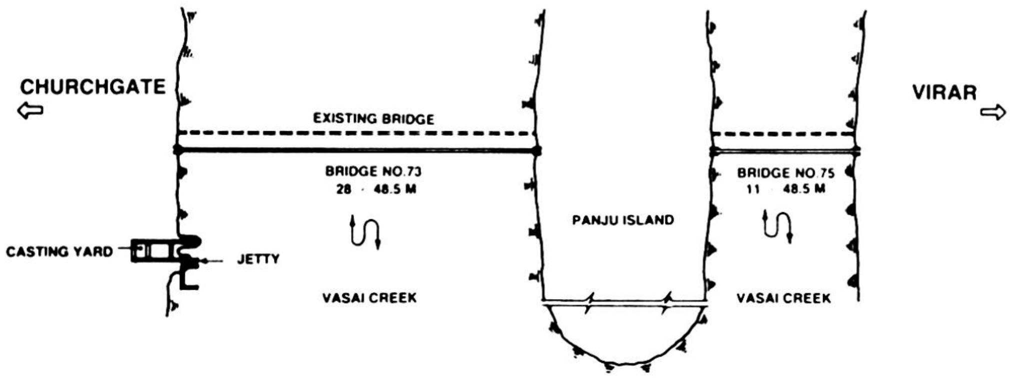

Fig.1 Layout of Bridges and Casting yard

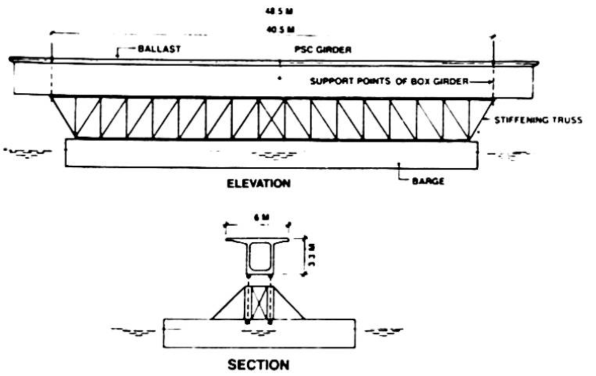

Fig.2 Detail of Launching Pontoon

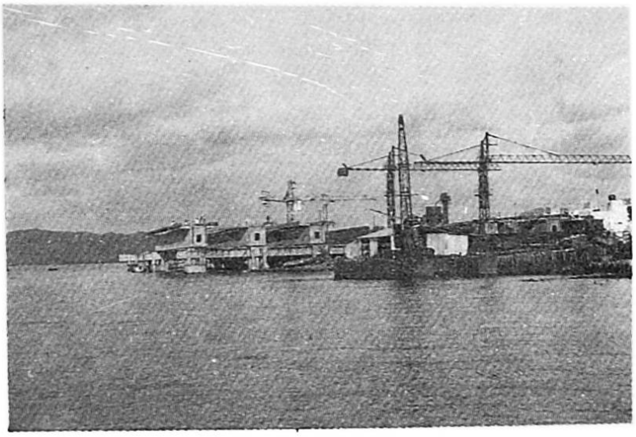

Fig.3 Casting yard with girders

lowered on to its final position. By the judicious use of a number of anchors and winches mounted on the pontoon pulling against the anchors, the positional accuracy could be controlled to within two centimeters. The height of the spreader truss on the launching pontoon was designed to correlate to the relative levels of tides and the final placed elevation of the girders, The level of the launching jetty was also designed accordingly. The longitudinal gradients in one of the bridges was also taken into account. Dredging was carried out at a few locations near shore to ensure sufficient draught for the pontoon. By proper management of the casting and launching cycles a peak speed of seven girders per month was achievevd.

2.3 Casting Yard

For the casting yard free land was not available and land had to be reclaimed from the creek. The casting and stacking beds had to be located on piles and considering the limited availability of land and the high costs of reclamation and piling, an optimal layout of casting and stacking beds was evolved and the sequence of casting, finishing and launching accordingly planned. In view of the time constraints two launching jetties were used with a total of four casting beds and seven stacking beds where finishing operations were carried out.

2.4 Design Optimisation

In order to minimise the cost and to reduce the weight of the girder the concrete thicknesses were optimised all along the length of the girder with

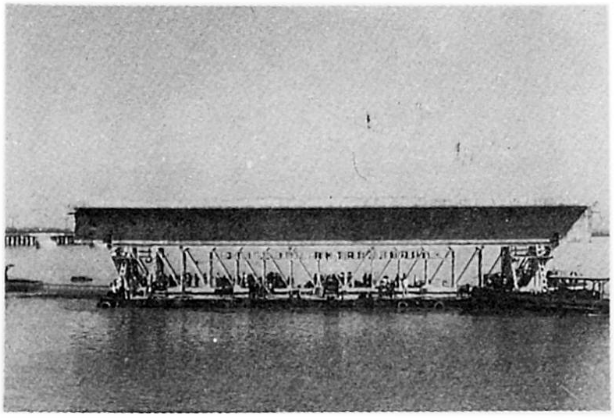

Fig.4 Girder being towed.to location

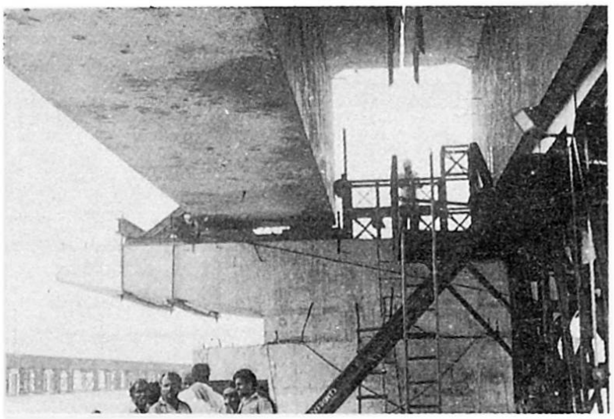

Fig.5 Girder about to be placed

thicknesses of deck and soffit slabs and webs varying along the length. This variation did not pose much problem for construction since precasting was done at one location using a properly designed shuttering scheme. At locations of minimum thicknesses of webs all the prestressing cables were located in the soffit slab, thus eliminating obstructions to concreting.

2.5 Conclusion

A high level of quality was achieved with the adoption of precasting to complete all the operations at shore itself under close supervision and a good speed of construction was achieved with the method of launching adopted.

3. SECOND THANE CREEK ROAD BRIDGE

3.1 Description

When completed this 1.835 km long bridge will form an important link between Bombay and New Bombay. The bridge comprises two independent decks with independent foundations each carrying three lanes of traffic and a footpath. The length of the bridge is made up of six continuous units of typical length of 321 m, with the typical span being 107 m. Each deck has a single cell prestressed concrete box girder of depth varying from 3.5 m to 7 m. Two foundations are with wells/caissons and the others are open foundations, all being socketed into rock.

3.2 Cofferdam Scheme

For the construction of the open foundations in the Creek in order to facilitate working and to cast all RCC under dry conditions, cofferdams were provided. Depending on the depth of water and the depth of bed material above rock, two schemes were evolved. The scheme adopted in the central reaches of the Creek involved an assembly of a lower precast concrete cofferdam and an upper cellular segmental steel shell, with the assembly being handled by a floating gantry. The circular thin-shell concrete cofferdam is precast near shore on a pontoon and brought below the floating gantry. The gantry picks up the cofferdam and the pontoon is withdrawn. While the gantry is holding the concrete shell, the steel shell is added in rings with four segments in a ring, to the required height. Then the assembly is lowered down, the inside bed

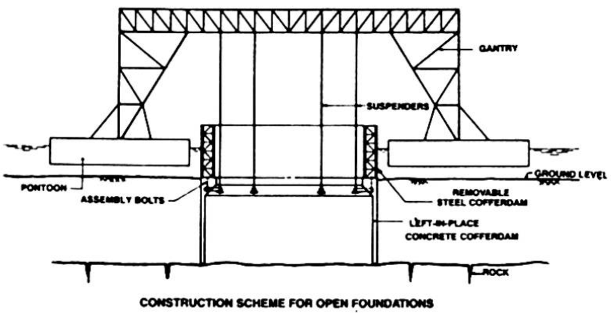

Fig.6 Detail of floating gantry with cofferdam assembly

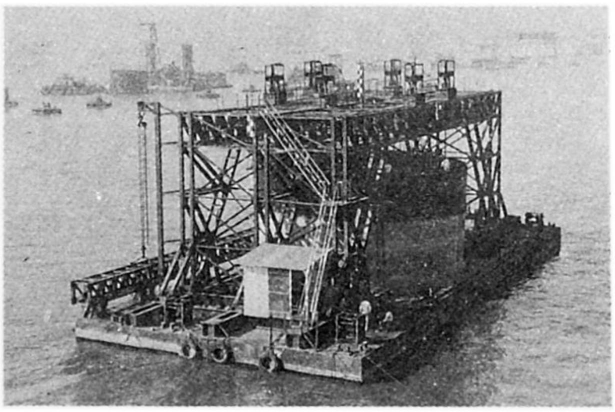

Fig.7 Cofferdam being lowered

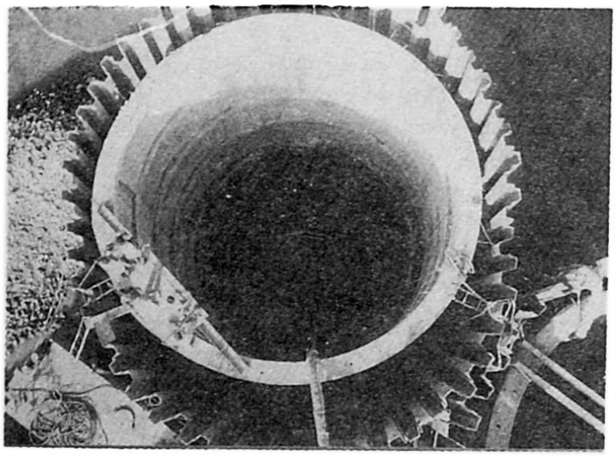

Fig.8 Cofferdam inside sheetpile

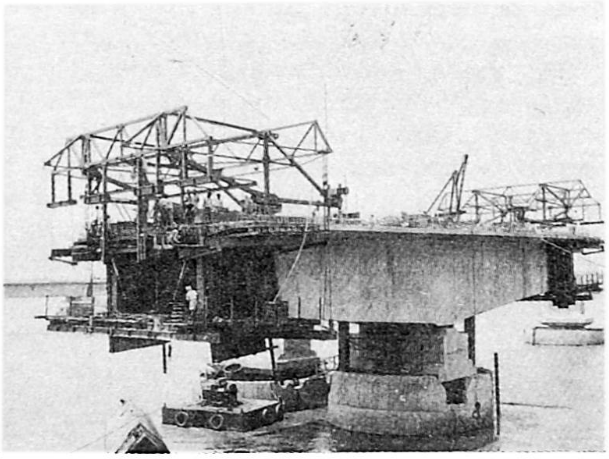

Fig.9 Superstructure cross section

material excavated and the concrete cofferdam seated in rock. The gap between the cofferdam and rock is sealed with an in-situ concrete ring to enable dewatering of the enclosure. After rock cutting the foundation is inspected in dry and the concrete elements of the foundation are built up. Once the foundation comes up above water level, the upper steel shell is dismantled and taken away for reuse and the concrete shell left in place. In the reaches near the shore a sacrificial thin shell concrete cofferdam is cast on sand filling formed inside a steel sheet-pile enclosure and sunk like a conventional well/caisson upto rock. Thereafter the balance operations are as for the other method.

3.3 Design features

The design was evolved to suit this method of construction. The foundation consisted of a PCC plug at the bottom inside a cavity in rock, topped by an RCC pedestal and then a tapered RCC pier.

3.4 Superstructure

The superstructure construction is with cast in-situ balanced cantilever method of construction. To achieve continuity, the key segment between two cantilever tips is cast in-situ. To facilitate the casting of the deep webs prestressing cables were completely eliminated from the webs and located fully in either deck slab or soffit slab.

4. SUPERSTRUCTURES FOR THREE RAILWAY BRIDGES NEAR AROOR-KUMBALAM

As part of the new broad gauge railway network near Cochin three bridges spread over 3 km length had to be built over marine backwaters. The superstructure consisted of 30.5 m long simply-supported spans. The three bridges had 29, 5 and 4 spans respectively. Lack of space at the construction site for storing materials or for a precasting yard posed a problem for the adoption of any conventional method of construction. It was then decided to adopt precast segmental construction. The span was precast in seven segments by the long-line match-casting method in a casting yard located seven km from the site. The segments were brought to site on a pontoon pulled by a tug. For assembling the segments two independent rectangular assembly trusses moved over the pier caps. Underslung cross trusses located between the two main trusses supported the segments.

The segments were picked up by an overhead crab moving over the main trusses, placed on the cross trusses, painted with an epoxy formulation on the match cast faces which also had a number of shear keys and pressed together using temporary prestressing cables. Then permanent cables were threaded through, stressed and grouted. Thereafter the cross trusses were removed and the assembly trusses were moved forward to the next span with the forward end resting on a trestle located on a pontoon and the rear end supported by a trolley moving over the previously erected span. The maximum weight of a segment was 35 t and a span could be completed in one week's time.

5. CONCLUSION

The foregoing examples demonstrate that Indian technology can tackle major bridge projects by evolving simple but effective construction solutions to suit the site constraints and infrastructure available.

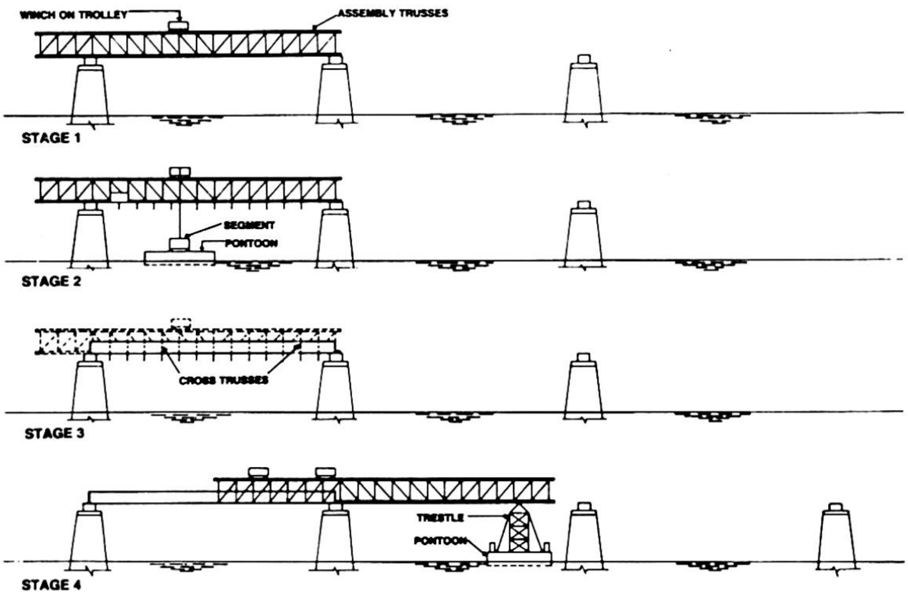

Fig.10 Sequence of assembly of superstructure

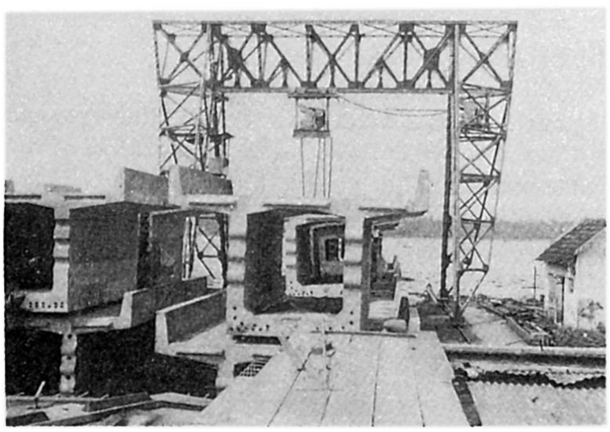

Fig.11 Casting Yard

Fig.12 Assembly Truss