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Autor: Chatterjee, A.K. / Dharap, V.M.

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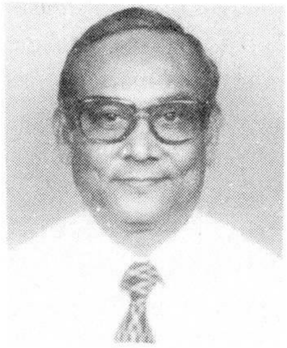
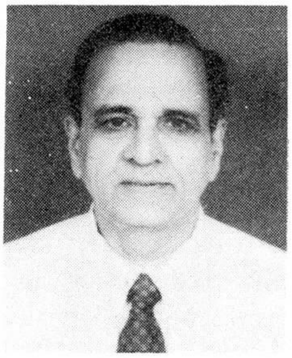
PROBLEMS OF CONSTRUCTION OF CAISSON FOUNDATIONS OF THE SECOND HOOGHLY BRIDGE (VIDYASAGAR SETU) AT CALCUTTA AND THEIR SOLUTIONS

A.K.Chatterjee, Sr. Vice President, Gammon India Ltd., Mumbai, India. Born 1938, Bachelor of Engineering(Civil), Calcutta University, employed with Gammon India Since 1960





V.M.Dharap, Sr. Vice President, Gammon India Ltd., Mumbai, India. Born 1937, Bachelor of Engineering(Civil), Poona University, employed with Gammon India since 1969

SUMMARY:

The 822.96 m long cable stayed bridge, over river Hooghly at Calcutta, with a central span of 457.2 m and named "***Vidyasagar Setu***", is one of the most outstanding long span bridges not only in India but also in the world. Vidyasagar Setu was planned and constructed to relieve the extraordinary congestion of traffic over the other old existing long span bridge, nearby, popularly known as the "***Howrah Bridge***".

This new bridge has two carriageways of three lanes each separated by a median verge and has a clearance of 30.0 m above the HTL to allow passage of oceangoing vessels. Each of the four foundations of the bridge, comprise of twin circular caissons. The location of the foundations and the caisson diameters are as below:

F-1 comprising of twin caissons on Calcutta bank	:	12 m
F-2 comprising of twin caissons on Calcutta bank	:	20 m
F-3 comprising of twin caissons on Howrah side but inside the river	:	23 m
F-4 comprising of twin caissons on Howrah side and inside the river	:	8 m

In the background of influencing factors e.g. high sensitivity of river regime, navigational traffic, the alluvial nature of the bed, high expected long term settlements, and the need to minimise them, several challenging problems of complicated nature were encountered in design and construction particularly for foundations F-2 & F-3. The paper describes the various techniques of construction adopted to meet the challenges particularly those connected to the tower foundations F-2 & F3 and touches upon the problems related to the anchor foundations F-1 & F-4, the design concepts and the methodologies applied, to overcome the problems, that finally enabled the emergence of this aesthetically pleasing bridge.

1.0 LAYOUT

The general elevation and plan of the bridge is shown in fig.1 and the layout of F-3 and sections in fig.2. Layout of F-2 is similar to F-3, but the length of the pier in plan is slightly lesser than the pier over F-3. Layout of F-4 is shown in fig.3. F-1 is similar to F-4 but with larger sizes. Photograph 1 shows a view of the completed bridge.

2.0 THE PROBLEMS FOR CAISSONS UNDER F-2 & F3 AND THE SOLUTIONS.

2.1 Problems connected to the construction of the caisson plugs

Originally it was required that the bottom plugging be carried out in the dry. This could have been achieved by plugging under pneumatic conditions only, if to be done in one operation. However to obviate risks and dangers associated with plugging under pneumatic condition under a large head of water, pneumatic plugging was ruled out, as a measure of prudence and abundant caution.

2.2 The solutions and methodology finally adopted to overcome the problem

On examining other alternatives, a safer and satisfactory alternative of forming the plug in two stages, was adopted. In this methodology an under water plug in colcrete/concrete to sustain base pressures due to self weight of caisson and the vertical pressure caused under the plug by a hydrostatic head reckoned from HTL or LTL, after placing vertical steel bond bars in this plug for eventual integration, was cast in the first stage. After curing followed by dewatering, a layer of RCC plug over the first stage plug was cast in dry and cured to integrate with the first stage plug. Both these plugs were individually and integrally designed to sustain the various stage loadings that would be incident on them including the service loading. Fig.4 shows the typical integrated plug.

2.3 The problem of casting the caisson caps for F-2 and F-3

To cast the heavy capping slabs, an elaborate and supporting system would normally have been required, even though constructing such a structure in dry was possible. However this would have been uneconomical and time consuming.

2.4 The solutions and methodology of construction

Precast concrete shuttering slabs were designed to sustain the self weight of the caisson cap. Connector reinforcements were provided to integrate them monolithically with the caisson cap which was designed to cater for loadings that would occur under service. These precast slabs being light, in actual construction, handling was not difficult and the system worked well and successfully during actual construction.

3.0 PROBLEMS OF CONSTRUCTION OF CAISSONS FOR F-3

3.1 The problem

The river is sensitive to silting and scouring even with slight disturbances in regime conditions. To obviate destabilisation of the bed, large obstructions to the river flow was considered undesirable. Construction of caissons with the aid of cofferdams was therefore ruled out.

3.2 The solution and methodology of construction

The alternative of constructing by the floating caisson method was adopted. The depth of water at the foundation location was about 15.0 m during high tides. Structural steel caissons 22 m high and weighing about 800t were used. Initially an 8.0 m high steel caissons weighing about 360t were assembled over a specially designed tilting slipway platform (photograph 2), launched into the river during the high tides and transported to location by tugs. The steel caissons were aligned by using very high precision theodolites and distance measuring units (distomats) from two survey stations on opposite river banks and one survey station constructed in the river on the upstream side of the location. The caissons were grounded at the location using a combination of concrete and water ballast providing the flexibility to refloat the caisson in an eventuality. The design and construction of the steel caissons, tilting slipway platform, floating operation, anchoring arrangement, towing operation, alignment and grounding and sinking operations, including many other associated activities needed a very detailed investigation and meticulous planning to achieve the desired results, which was very successfully done at site. Photograph 3 shows caissons of F-3 under construction.

3.3 The problem of constructing the pier over F-3

As mentioned above, obstruction to water way had to be minimum. Therefore the top level of the caisson was kept very low at +0.609 KODS i.e. 6.76 m below high tide level. Construction of caisson caps and part of the pier system had therefore to be carried out underwater, throwing a serious challenge.

3.4 The solution and methodology adopted

A circular RCC wall of short height was constructed over the outer wall of the twin caissons followed by the construction of 7.0 m high dismantlable circular steel cofferdams. The caisson caps and a part of the pier box was then cast within the circular cofferdam upto a height slightly above the HTL. Four temporary RCC columns were cast alongside the partly cast pier boxes to support steel trusses spanning over the twin caissons. Thereafter a 6.0 m wide & 16.0 m long portion of the connecting pier beam weighing 600t approx., in the shape of a trough and being a part of the pier system, was cast above the high tide level. The soffit shuttering for this pier beam was supported by a support system suspended from the truss. A portion of the circular steel cofferdams was dismantled and the pier beam partly cast with the truss support, was lowered into position by means of hydraulic jacks and seated over brackets provided at the soffit level of the caisson caps. Vertical steel gates were then erected on the outer faces of the pier walls at the junctions between the connecting pier beam and the pier box. These gates were sealed with the help of divers. Thereafter the pier box with the pier beam was dewatered completely, which resulted in a very effective sealing by water pressure from outside. The junction at the soffit slab level and between the pier walls were integrated by insitu concrete. The joints were shaped in the form of saw-tooth type castellations with connector reinforcements for proper shear transfer. The steel cofferdams were then completely dismantled and the rest of the pier box above the HTL and the pier cap constructed in the conventional manner. A difficult part in this construction was to achieve the enmeshing of the horizontal bars of the pier boxes and the connecting beam, and the vertical bars of the steining. Hence every space between the steining bars was actually measured and a layout drawing made. The horizontal bars in the pier beam were slightly adjusted before lowering to enable a smooth passage.

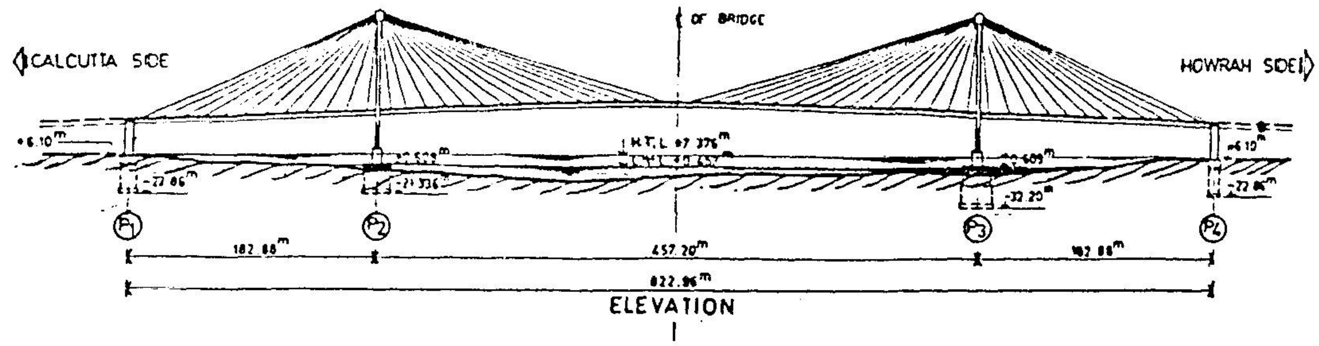
4.0 THE PROBLEMS OF F-1 & F-4 AND SOLUTIONS

Being land based foundations no extraordinary problem excepting during sinking the caissons, was encountered. The slight difficulty in sinking during the last few metres was overcome by providing a moderate kentledge. Normal underwater plugging was carried out on completion of sinking.

5.0 CONCLUSION

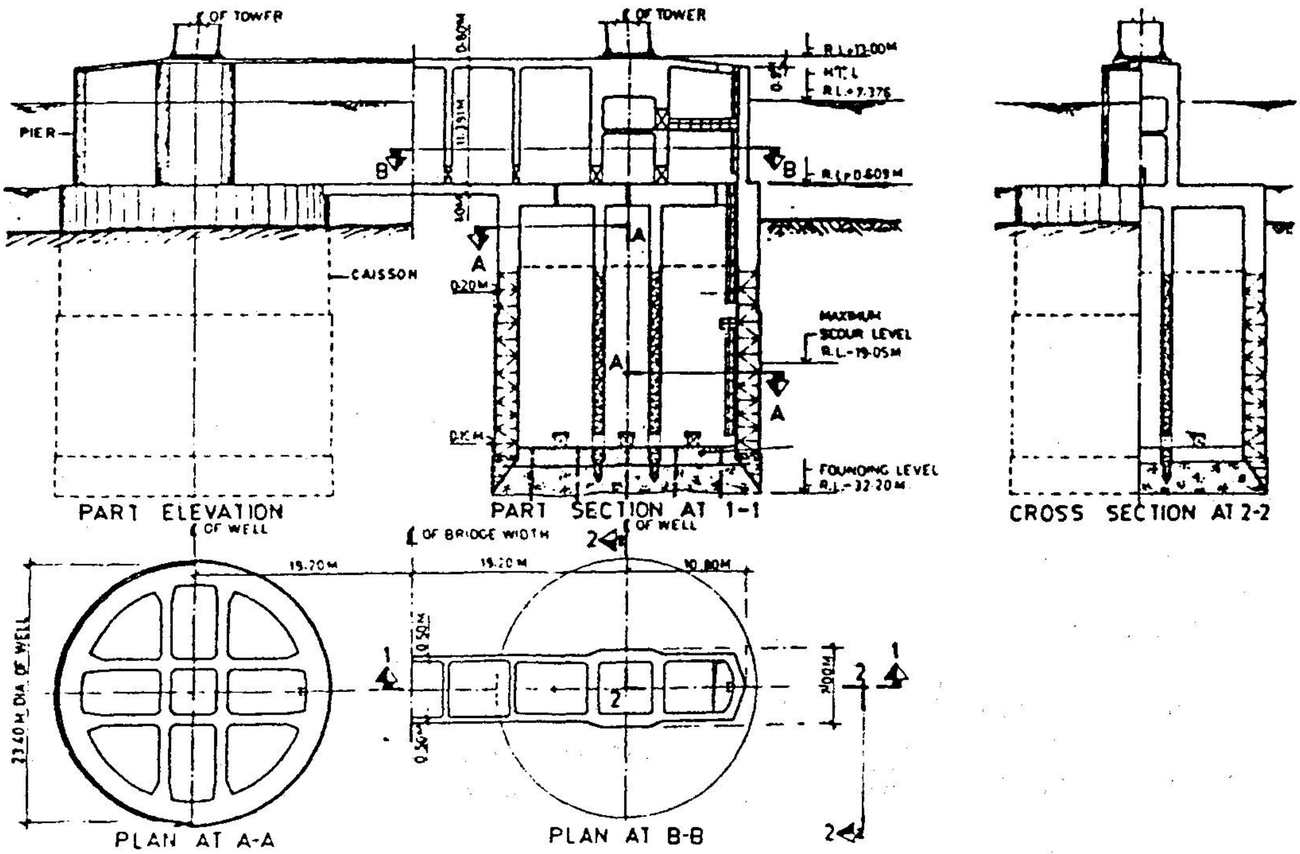
As described above, the construction of the foundations and substructure of 'Vidyasagar Setu' provided many challenges to the design and construction engineers. It can be said that the experience gained by the engineers in tackling the design and construction problems would provide the knowledge that could be drawn upon to help resolve similar problems expeditiously in future projects of this nature.

Acknowledgement: Hooghly River Bridge Commissioners



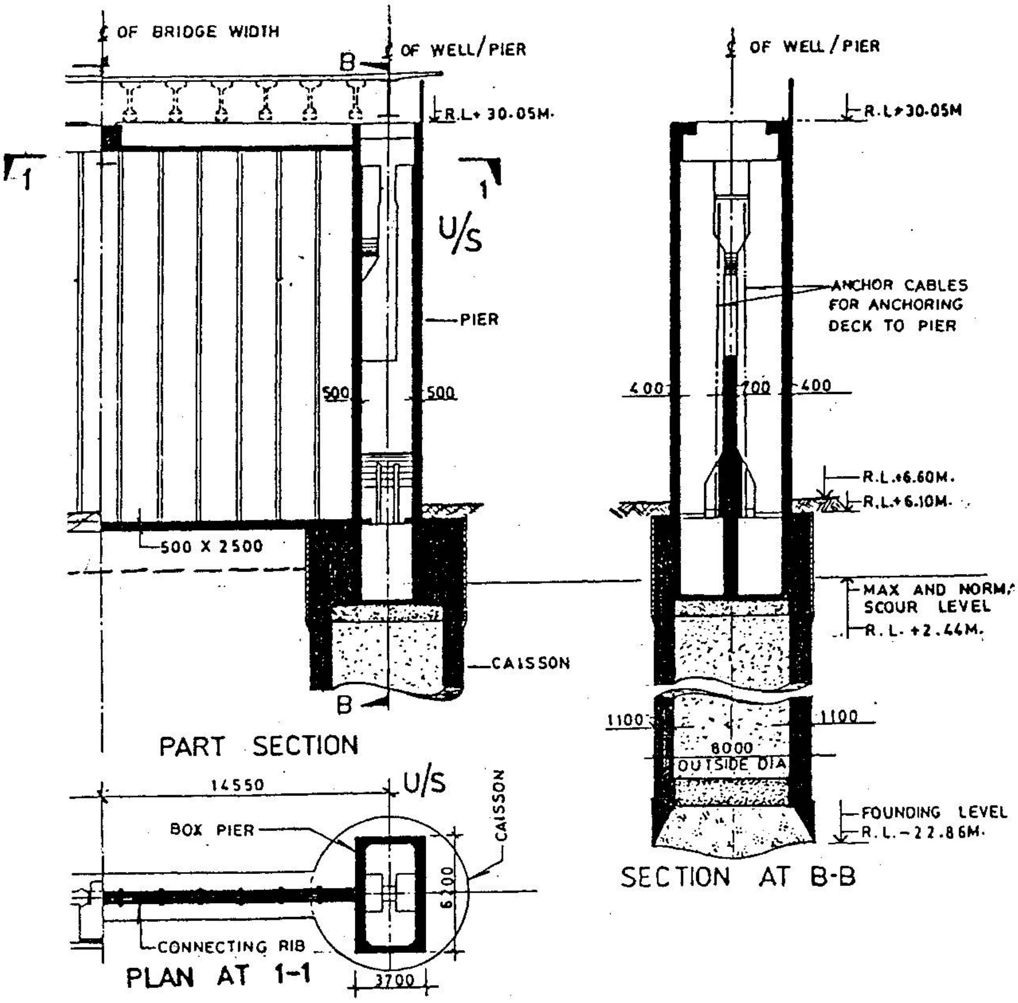
SECOND HOOGHLY BRIDGE

FIG. 1



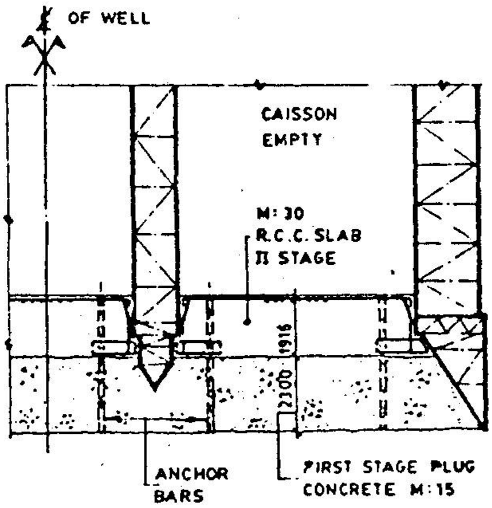
PIER P3 AND CAISSONS F3

FIG. 2



PART PIER P4 AND ONE CAISSON OF F-4

FIG.3



PART CROSS SECTION SHOWING BOTTOM SLAB REINFORCEMENT

BOTTOM PLUG FOR CAISSON OF F-3

FIG. 4

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