Bridge on the river Ganges at Buxar, India

Autor(en): **Subba Rao, T.N. / Harridas, G.R.**

Objekttyp: **Article**

Zeitschrift: **IABSE proceedings = Mémoires AIPC = IVBH Abhandlungen**

Band (Jahr): **4 (1980)**

Heft P-28: **Bridge on the river Ganges at Buxar, India**

PDF erstellt am: **09.08.2024**

Persistenter Link: https://doi.org/10.5169/seals-34953

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

Bridge on the River Ganges at Buxar, India

Pont sur le Gange à Buxar, Inde

Brücke über den Fluss Ganges, Buxar, Indien

T. N. SUBBA RAO
Managing Director
Gammon India Limited
Bombay, India

G. R. HARRIDAS
Deputy Technical Manager
Gammon India Limited
Bombay, India

SUMMARY

The paper describes the design and construction of the high level road bridge across the river Ganga at Buxar, in India. This prestressed concrete long span bridge is built by the cantilever construction technique, using in situ as well as precast segments. Large diameter R.C.C. caisson foundations support a single cellular box decking over R.C.C. cellular piers. The decking, designed as a semi-continuous frame, incorporates cast-steel pendulum bearings at the mating cantilever arms. The prestressing cables consist of 24 wires of 7 mm dia and are anchored by Freyssinet twin 12/7 mm anchorages. The precast segments have been match cast. The project involved many innovations to be tried out for the first time in India.

RÉSUMÉ

L'article décrit le projet et la construction d'un pont-route sur le Gange à Buxar en Inde. Cet ouvrage de grande portée en béton précontraint est construit par encorbellement, utilisant tant le béton coulé sur place que des segments préfabriqués.
Les fondations, constituées par des caissons en béton armé de grand diamètre, supportent un caisson unique par l'intermédiaire de piles cellulaires en béton armé. La superstructure a été prévue comme un portique semi-continu comprenant des appuis pendulaires en acier au droit des extrémités des encorbellements. Les câbles de précontrainte consistent en 24 fils de 7 mm de diamètre et sont ancrés au moyen d'un double ancrage Freyssinet 12/7 mm. Les éléments préfabriqués ont été coulés en utilisant les éléments adjacents comme coffrage. Le projet présentait de nombreuses nouveautés, qui ont été réalisées pour la première fois en Inde.

ZUSAMMENFASSUNG

Es wird über Entwurf und Erstellung einer Strassenbrücke über den Ganges in Buxar, Indien berichtet. Diese Spannbetonbrücke mit grossen Spannweiten wurde in Freivorbau erstellt, unter Verwendung von Ortsbeton und vorfabrizierten Teilen. Grosse Senkkastenfundamente tragen die kastenförmigen Pfeiler. Der Überbau enthält am Ende der Kragarme, also in den Feldmitten, stählerne Pendellager und wirkt so als „halbdurchlaufender" Rahmen. Die Vorspannkabel bestehen aus 24 Drähten von 7 mm Durchmesser und sind in einem Freyssinet 12/7 mm Doppelanker verankert. Die vorfabrizierten Teile wurden jeweils unter Verwendung des vorhergehenden Elements als Schalung betoniert. Das Projekt zeigt viele Besonderheiten, die in Indien zum ersten mal verwendet wurden.

1. THE TERMS OF REFERENCE FOR THE DESIGN OF THE BRIDGE AND ITS CHOICE

1.1 Location :

Buxar Bridge is located in an area of fine scenic beauty on the Gangetic plain, where the river Ganges widens itself to over 1000 metres during the floods, caused not only by melting of the snow from the Himalayan Ranges in summer but also due to North-Easterly monsoon rains during winter. The flooded river was causing considerable inconvenience to traffic, as the existing road route sans the bridge is on an important highway network. With the nearest bridge being 250 Km away, the imperative need for locating a new bridge at this location was apparent.

1.2 Planning :

The river bed being susceptible to heavy errosion (upto 20 M) during floods, with fine to coarse alluvial strata, caisson foundations of over 45 M depth were found to satisfy the design parameters.

The river carries navigational traffic, and hence the decking in the central three spans had be planned so as to have spans ranging from 90 M to 110 M. Similarly, to allow for the ships to pass freely under the decking, it was necessary to provide a high level bridge with a minimum vertical clearance of 9.50 M under the worst floods. All this demanded a bridge with long spans and competitive pricewise.

A prestressed concrete decking offered the best possible solution, demanding least possible subsequent maintenance as compared to a structural steel proposal. A prestressed concrete box decking using cantilever - construction technique was chosen, as it gave the optimum utilisation of available resources, combined with elegance, to fit into the natural surroundings.

2. GENERAL ARRANGEMENT

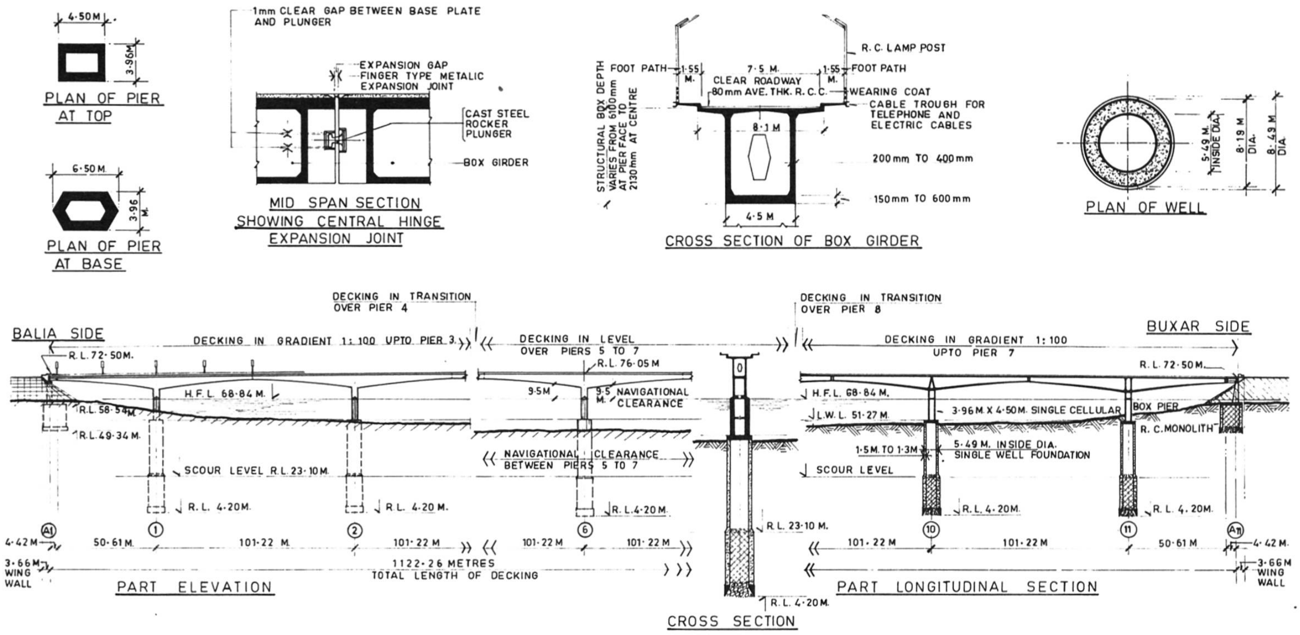
2.1 Layout :

The bridge is 1122.26 M long between end to end of decking and consists of 10 intermediate spans of 101.22 M each and 2 end spans of 55.03 M each. The intermediate spans are formed by mating two equal cantilever arms of 50.61 M each; the end spans consist of a 50.61 M cantilever arm supporting a short reinforced concrete riding span (see figure 1). The decking provides for 7.5 M clear roadway, 1.5 M footpaths on either side and provision for carrying telephone and telegraphic cables alongside. The decking is sloped up a gradient of 1 in 100 from either end in order to provide sufficient navigational clearance under the central 3 spans.

2.2 Superstructure :

The superstructure consists of a single cellular box of overall width 4.5M over the webs, and 8.1 M at the deck level, and has a variable depth ranging from 6.1 M at the pier-face to 2.13 M at mid-span. The thickness of the web varies from 0.40 M to 0.20 M and that of the soffit slab from 0.60 M to 0.15 M to enable optimum utilisation of materials. The box

Fig.1: General arrangement



deck is progressively constructed in either insitu or precast segments, prestressed by post-tensioned Freyssinet cables. The short riding span is of twin R.C.C. girder-slab type, constructed with its external faces matching with that of the box deck. The mating cantilever arms in the intermediate spans are connected through cast-steel pendulum bearings, located in the webs, to provide smooth riding transition. The reinforced concrete riding spans are supported over mild-steel rocker and rocker-cum-sliding bearings.

2.3 Foundation and Substructure :

Each foundation consists of single circular reinforced concrete caisson of over 47 M depth, thus providing a minimum grip length of over 18.90 M under the worst possible scour conditions. The caisson has a uniform internal diameter of 5.49 M, with 1.50 M thickness below and 1.39 M thickness above the scour level. Each pier of the substructure consists of single cellular R.C.C. box pier of overall dimension 3.96 M x 4.5 M, as generally shown in figure 1. The pier is monolithic with the prestressed concrete superstructure above and is rigidly fixed to the caisson below.

3. DESIGN CONSIDERATION

3.1 Loading :

The bridge is designed for 2 lanes of Class A or 1 lane of Class 70R loading, ~~for~~ a seismic force of $\frac{G}{20}$, a differential settlement of 25 mm between adjacent foundations and a maximum water current flow of over 6 m/sec during floods with corresponding deepest scour level as shown in figure 1, all as per the provisions of the Indian Roads Congress code for design of bridges.

3.2 Design Analysis :

The basic design analysis is made using conventional theory of rigid box analysis and space frame and subsequently cross-checked for accuracy on a computer.

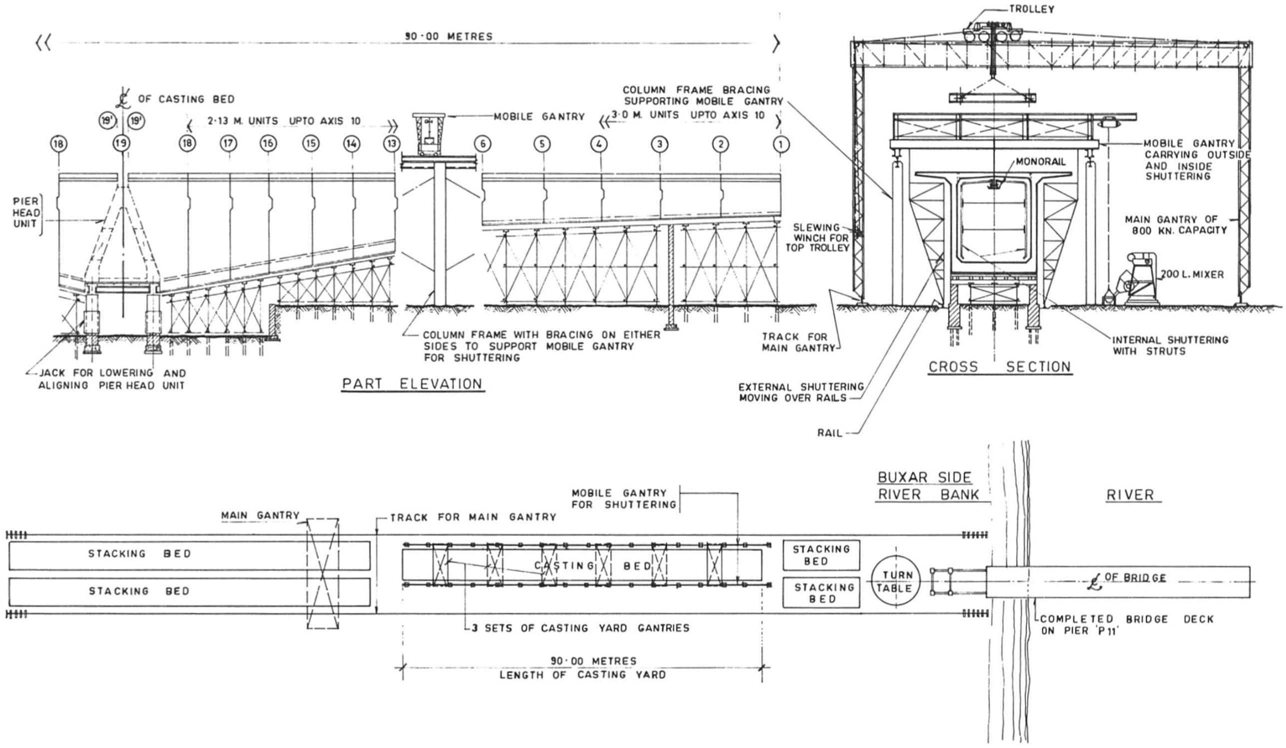
3.3 Concrete :

The prestressed concrete box decking has a minimum 28 days works cube strength of 44.5 N/mm^2 using 25 mm down aggregate; the R.C.C. riding spans, footpath and piers are in grade 34.5 N/mm^2; the caissons and other R.C.C. members are in grade 20 N/mm^2.

3.4 Prestressing :

Non-availability of high capacity tendons indigenously, led to the development of 24 Ø 7 mm Freyssinet cables using twin anchorages. The high tensile wire used for the cables has a minimum ultimate tensile strength (U.T.S) of 1600 N/mm2 and a 0.2% proof stress higher than eightyfive percent of the minimum U.T.S. In all seventytwo cables are required over each of the pier supports - the point of maximum bending moment. The tendons to be anchored in the web are so grouped that they are placed symmetrical to the centre line of the given web thickness and have identical trejectory.

Fig.2: Layout of casting and stacking yard



3.5 Non-tensioned Reinforcement :

The superstructure is reinforced with high yield deformed bars of grade 420and the substructure and foundation with mild steel rounds of grade 240.To ensure effective concreting with some compaction and quality control, careful detailing of the reinforcement and cable positions was given much attention. The soffit reinforcement which is the least anywhere in the box deck, is taken into the web and only such extra reinforcement as demanded by design was added in the web. In a similar manner, the web reinforcement is extended into the deck slab and additional reinforcement provided.

3.6 Bearings :

The cast steel pendulum bearings at the junction of the mating arms at the centre of each span provide the necessary semi-continuity to the structure, by transferring only vertical shear forces and without restricting free longitudinal movement of the decking. The bearing is designed for the unbalanced forces caused perdominantly by live loads and differential settlements.

To minimise the torsion in the girders of the riding span deck at each end of the bridge, a 10 mm thick neoprene pad is sandwiched between the girder and at the supporting bearings which are of rocker and rocker-cum-sliding type at opposite ends.

4. CONSTRUCTION

All the temporary works, including the equipments required for the job were designed and fabricated indigenously.

4.1 Foundations :

The caissons were sunk by conventional sand islanding method using wooden piles and sand bags for a depth of water of 8 M in the river during minimum off season water level condition. The diversion of water flow by constructing groynes at critical locations about 2 Km upstream of the river, was of much help.

4.2 Superstructure :

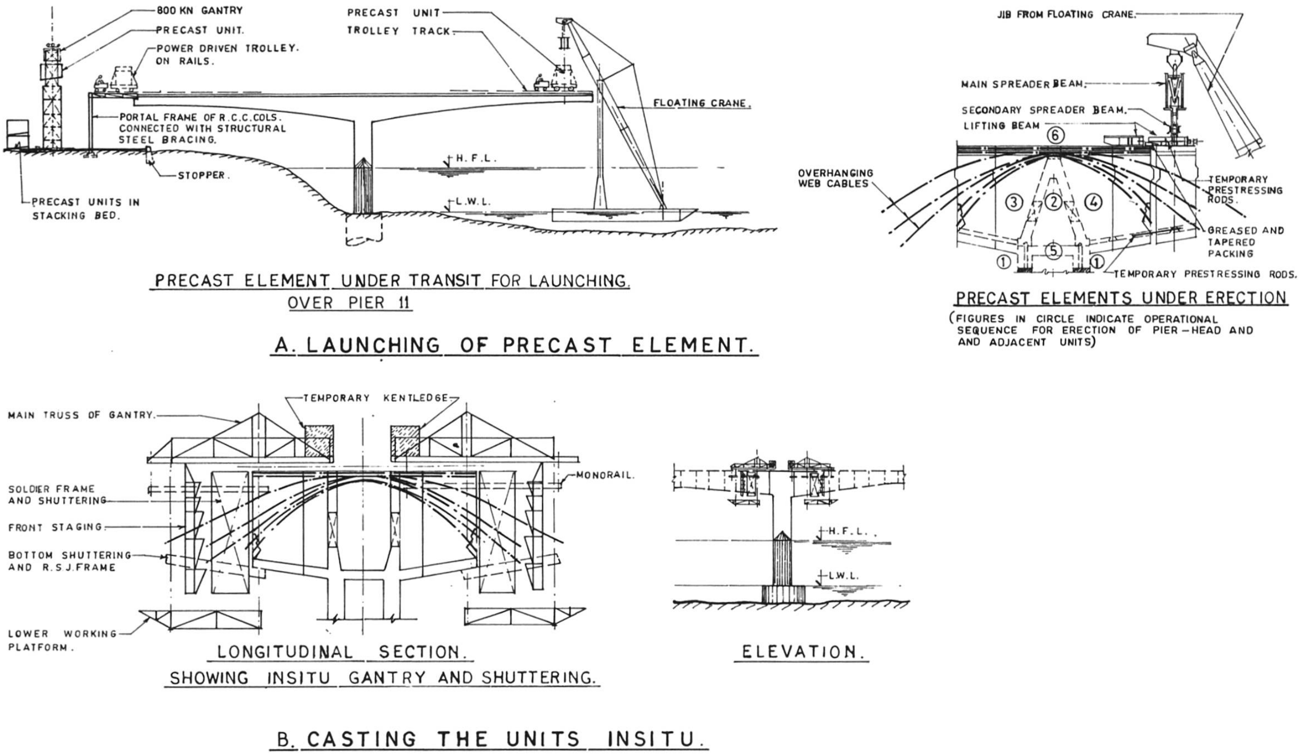
4.2.1 Insitu Decking :

In order not to loose time when the precasting technique was getting perfected, it was thought prudent to take up insitu concreting of a few of the Tee arms and hence the first one to be taken was on pierNo.11; this later on enabled easier transportation of the precast elements over foundation 11, to the forward lifting point within reach of the floating crane.

The insitu gantries were also indigenously designed and fabricated out of mild steel structurals and weighed upto 450 kN including shuttering and other components (see figure 3). The average time cycle with insitu gantries was 10 days per pair of symmetrically placed units (6 m length).

The central 11.22 M portion of the mating arms of all spans were cast-insitu to facilitate placing of the cast-steel pendulum bearings.

Fig.3: General arrangement showing different construction techniques



4.2.2 Precast Decking :

The casting yard had to be carefully planned, as the precasting of the box units was carried out for the first time in India (see figure 2). Limitation in the lifting capacity (650 kN) of the floating equipment demanded fixing of box elements of length 2.13 M nearer to the pier and 3.0 M in the balance portion of the span.

The casting bed is of fixed type and extends upto one Tee arm length (90 M). The entire area of the bed was piled in a predetermined manner in order to preclude the possibility of settlement of the supports under continuous use of the bed over a period of nearly two years. The bed consisted of brick walls on either side profiled to the shape of the soffit, directly below the web of the box girder. The soffit of the bottom slab of the box was supported by independent tubular staging. The sides and the soffit of the box both inside and outside, were supported from a mobile transverse girder which could be moved on longitudinal rails to various positions to enable casting of the precast units from pierhead (PH) upto axis 1. In order to speed up progress, 3 sets of such gantries were provided for each half of the Tee arm.

Initially, field tests were carried out to examine the smooth working of the system and easy removal of the precast units without damage. It was found that the removal of the earlier cast unit closer to the PH caused breakages in the shear keys of the webs and deck and the keys were, therefore, reshaped.

Astride the casting and stacking yard and traversing to a point beyond the turntable, a 800 kN capacity mobile gantry served the functions of lifting, stacking and loading of the precast units (see figure 2).

The shuttering for the central PH unit was supported on a combination of sand jacks and hydraulic jacks so that the unit could be raised, lowered or tilted as required.

Precasting of the units started from the PH unit. Having opted for a fixed casting bed, convenience of removal of the precast units demanded a triangularly shaped PH unit. Following the casting of this unit, the subsequent units were match cast. For removal of the precast units, the PH unit was first lowered with the help of sand jacks, this facilitated longitudinal shifting of the subsequently cast precast units before they were lifted off the bed and transferred to the stacking yard. Once unit 19'-18 was removed from the bed, the PH unit was lifted off the bed and transferred to the stacking yard.

The transition of the deck at piers 4 and 8 demanded the tilting of the PH unit after the unit 19'-18 was cast on one side and removed in the normal manner; this was accomplished by means of hydraulic jacks.

Stacking : The units were stacked horizontal upto 3 units piled one over the other but not exceeding 8 M height. Since the soffit is on a curve, the difference in the level of the soffit for horizontal stacking was made up by wooden sleepers. The units of each Tee arm were all marked and numbered to ensure perfect matching during erection.

Erection : The units were hoisted with the help of the main gantry on to a power driven trolley running on rails over the completed deck length (see figure 3). As the units were stacked in the same direction as cast, and picked up by the floating crane from front end only, they needed rotation by 90°/180° to enable erection from the side or front end as the case may be. Before the units reached their final position, the cables which were overhanging were threaded through them. The maximum length of the overhanging cables never exceeded 10 M. The system of threading of cables was such that the cables were threaded when they transited from the deck slab to the web. The unit was first checked for matching and alignment with the previously erected one. A specially developed epoxy formulation, successfully tried and tested by the R&D Wing of the Company provided an interfacial bonding surface with the match cast units and the epoxy mortar rarely exceeded one mm thickness in its final condition. Until the prestressing of this unit with the previous units already placed was carried out, the unit was held in position with the help of a system of hydraulic jacks placed both over the deck slab and the soffit slab and their pressure so regulated as to provide uniform compression on the epoxy. The prestressing was carried out after the symmetrical units on either side of a Tee arm were erected and temporarily locked to the previous units following application of the epoxy mortar. Openings were left in the web for locating the external cable anchorages; these were concreted progressively following erection of subsequent 2 units.

By taking up simultaneous erection on more number of Tee arms, a better control of deck levels and alignment as well as utilisation, was possible.

9 out of 11 Tee arms were constructed by using precast units. A maximum speed of 6 M of decking per day was achieved under favourable site conditions.

As in the case of the insitu deck, the central 11.22 M portion was also cast insitu and the pendulum bearing positioned.

4.3 Precamber :

The prestressed concrete box deck was given an upward precamber of the order of 75 mm at mid-span to account for the long-term deformations.

The precamber for the insitu decking accounted for the effects of the weight of cantilever construction gantries.

5. OTHER RELATED STRUCTURES

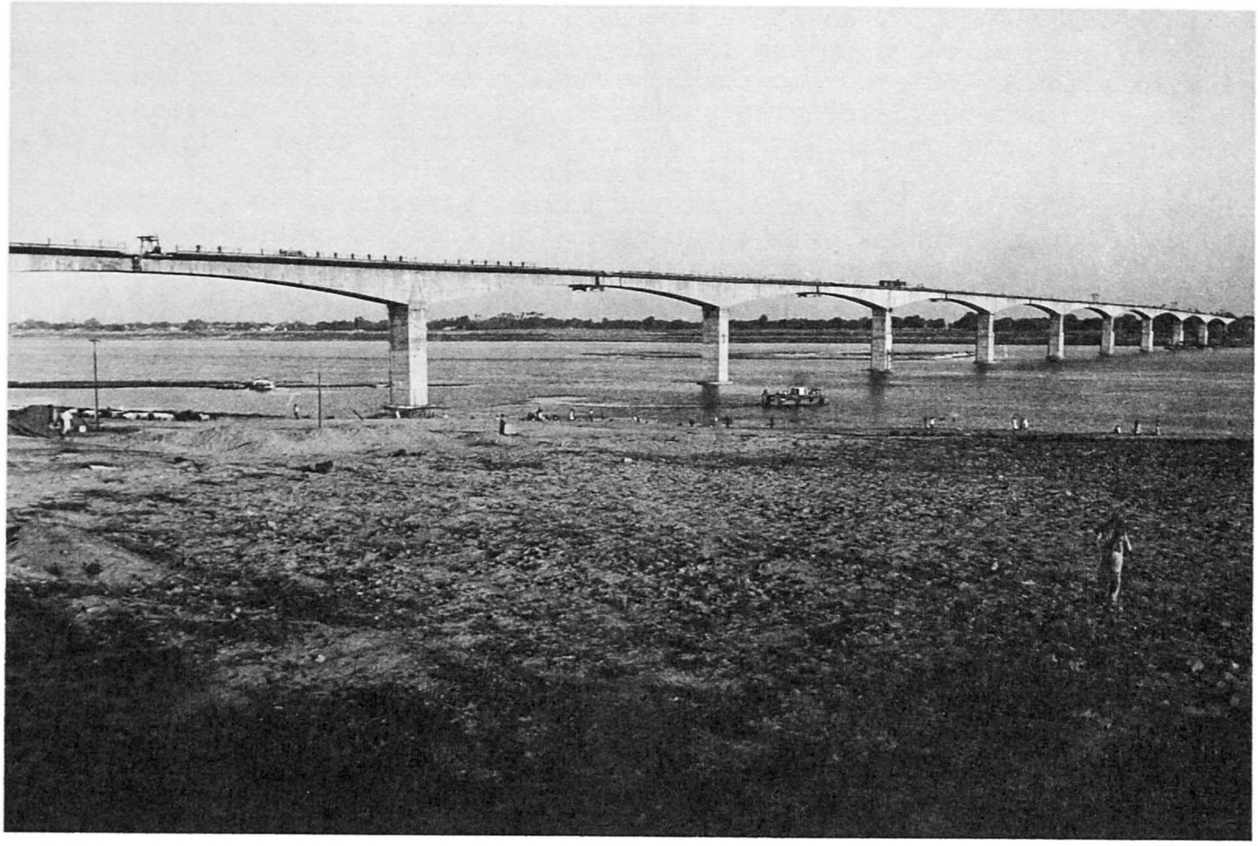
5.1 Footpaths :

To match with the aesthetics of the box decking, the footpath slab was also designed as a cantilever slab. However, to avoid possible development of cracks due to likely monolithic behaviour of the footpath with the main deck in sharing the super loads and time-dependent effects, the footpaths were cast-in-situ in 3 M units with cold joints.

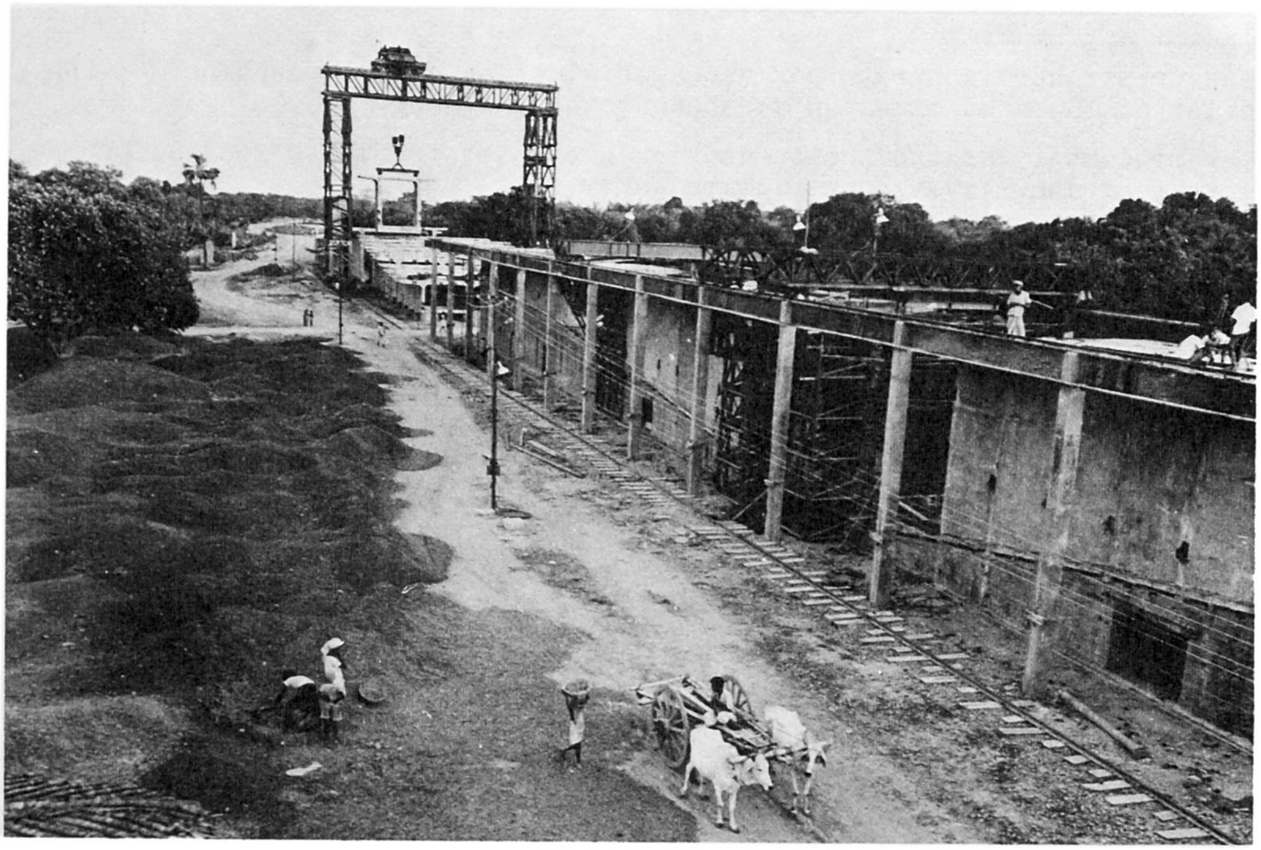
5.2 Expansion Joints :

The mild steel finger type expansion joints over the mating cantilever arms in the intermediate spans, provide necessary smooth riding quality for fast moving traffic.

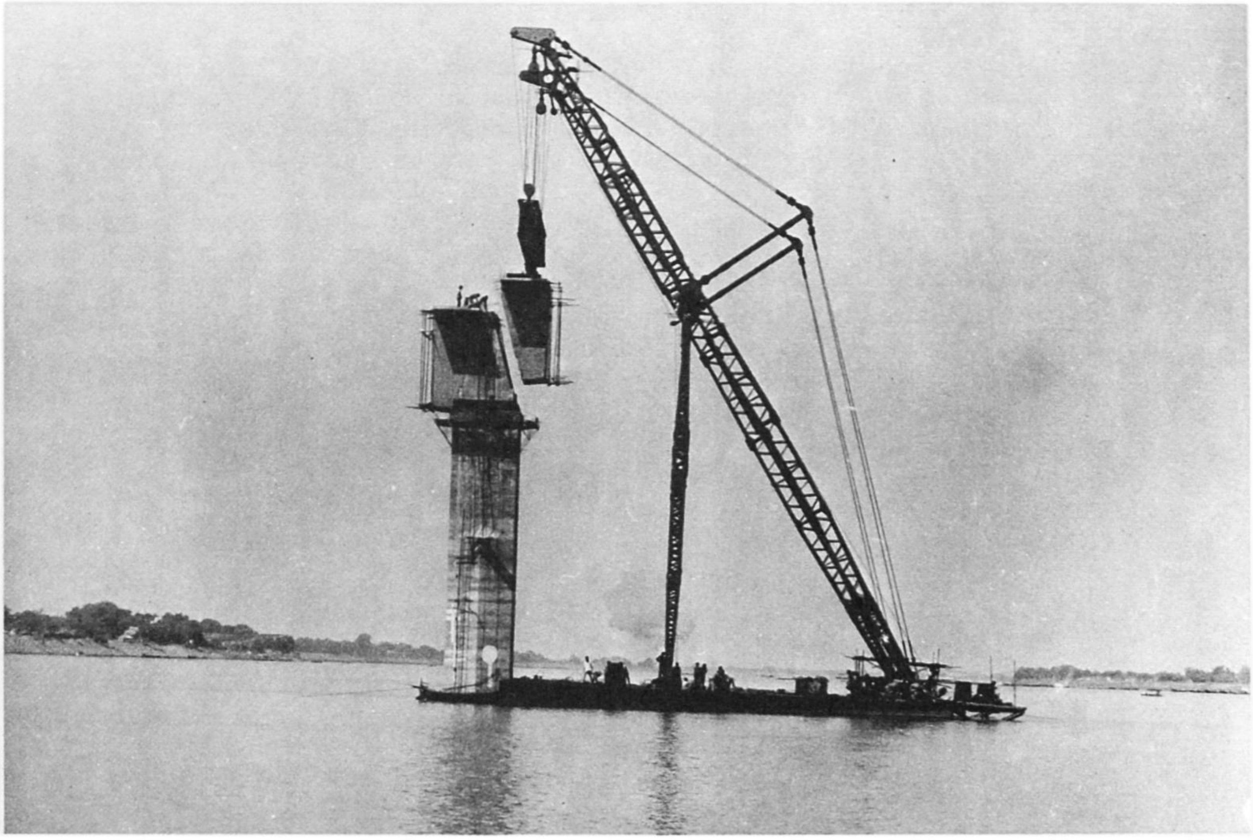
5.3 Railing is of precast reinforced concrete.



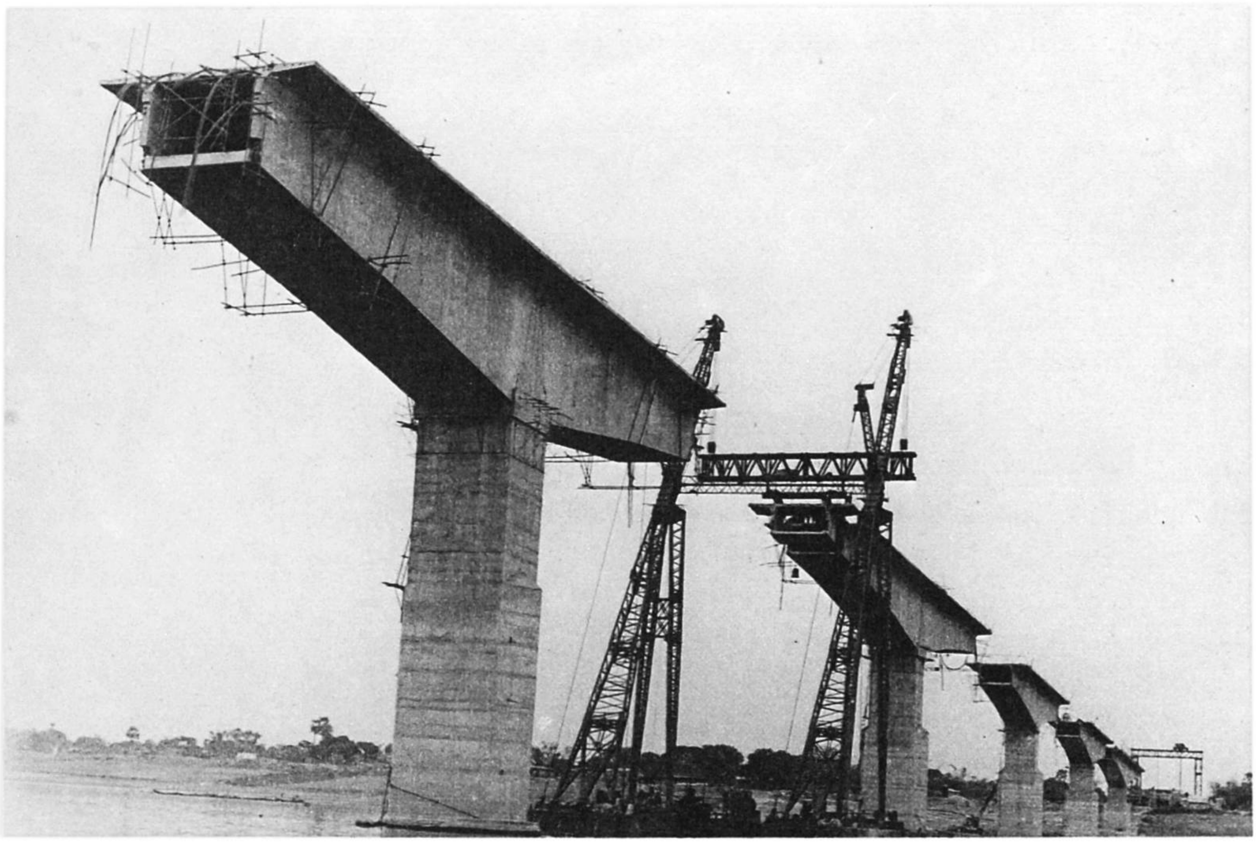
Photograph 1: General view of the Buxar Bridge under construction



Photograph 2: General view of the casting and stacking yard of Buxar Bridge



Photograph 3: View showing the erection of the precast unit adjacent to pierhead of Buxar Bridge



Photograph 4: General view of the Buxar Bridge showing the erection of a precast unit of Buxar Bridge

5.4 Wearing Coat :

The wearing coat is cast in R.C.C. 1:2:4 nominal mix and laid to a transverse camber with thickness varying from 65 mm at the road kerb to 95 mm at the centre of the roadway. The wearing coat over the transition piers 4 and 8 was profiled to give a smooth curve along the bridge axis at the formation level. It will be evident that each half of the Tee arm had a straight profile at deck slab lêvel because of the system adopted to cast them by rotating the PH, whereas the transition curve at the formation level had to be profiled to a curve, this necessitated increasing the thickness of the wearing coat over certain lengths of the Tee arm on either side (see figure 4 below).

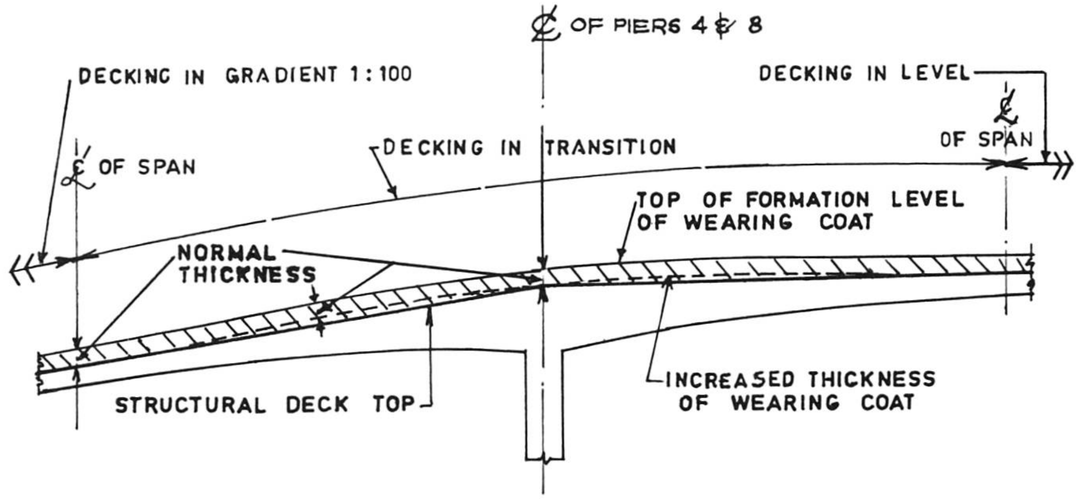


Fig.4: Thickness of wearing coat over transition piers 4 & 8

6. MATERIAL CONSUMPTION

The quantities used in the superstructure are :

Concrete of grade 44.5 N/mm^2	... 6450 M^3
High yield torsteel bars of grade 420 N/mm^2	... 6200 kN
High tensile steel of 1600 N/mm^2 UTS	... 4000 kN

ACKNOWLEDGEMENT

The successful construction of the bridge has been largely due to the alround cooperation and encouragement given by the Public Works Department of the Government of Bihar as also the Ministry of Transport, New Delhi, under whose aegis the bridge was designed and constructed.