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Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **14 (1992)**

PDF erstellt am: **09.08.2024**

Persistenter Link: https://doi.org/10.5169/seals-13883

Use of Precast Elements in the Construction of Delhi Flyovers

Eléments préfabriqués pour passages supérieurs à Delhi

Fertigteileinsatz bei Üebrfuhrungen in Delhi

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SUMMARY

The Delhi Tourism and Transportation Development Corporation, with a view to relieving the traffic congestion in the capital, has initiated a comprehensive transportation scheme entailing the construction of about twenty flyovers over the major corridors. An integrated systems approach was used in evolving the details of the flyovers and the resulting system uses precast elements extensively. It was also found that centralizing the precast factory is more economical than having one at every site. This paper presents the elements of the systems approach and also brief details of the central precast factory.

RÉSUMÉ

En vue de résoudre l'engorgement du trafic routier de la capitale, la Société des transports et du tourisme de Delhi a initié un plan global de transport, imposant la construction de plus de vingt passages supérieurs sur les axes de circulation les plus importants. Une étude intégrale des systèmes possibles a conduit à devoir utiliser les éléments préfabriqués pour la plupart de ces ouvrages. Cette analyse a également montré que la centralisation de la préfabrication dans une fabrique unique était plus rentable que la dispersion dans de multiples chantiers. L'article présente des éléments de l'étude des systèmes de construction ainsi que certains détails de la centrale de préfabrication.

ZUSAMMENFASSUNG

Als Abhilfe gegen die Verkehrsstaus in Delhi hat die Tourismus-und Verkehrsbehörde der Hauptstadt den Bau von etwa 20 Überführungen über die Hauptverkehrsachsen initiiert. Eine integrale Systemanalyse zur Erarbeitung der Konstruktions details führte zur ausgedehnten Verwendung von Fertigteilen. Ebenso ahellte die höhere Wirtschaftlichkeit einer zentralen Fertigteilfabrik gegenüber Feldfabriken. Der Beitrag stellte Elemente der Systemanalyse und Einzelheiten der Fertigteilfabrik vor.

1. INTRODUCTION

Like most of the metropolitan cities in the world, there has been in recent years an alarming growth in the vehicular population in the capital city of Delhi, resulting in heavy traffic congestion and high level of pollution due to the near crawling speed. In order to address this problem the Delhi Tourism and Transportation Development Corporation has initiated a comprehensive transportation scheme which includes inter-alia construction of about twenty flyovers over the major corridors of the capital.

The essential constraints are the speed and the ease of construction, minimum impedance to the existing traffic flow during construction without sacrificing overall economy and the aesthetics. In order to achieve the time-bound target, an integrated approach has been adopted right from the planning, designing and implementation. Moreover, respecting the site specific problems and conditions, system approach has been conceived with standardised design and construction.

This paper describes the system adopted for the successful implementation of the time-bound programme.

2. CONSTRUCTION METHODOLOGY, GEOMETRIC ARRANGEMENT AND SUPERSTRUCTURE SYSTEM

2.1 Construction Methodology

Since most of the corridors and the intersections are heavily loaded and offer very little scope for elaborate traffic diversion, adoption of precast elements for suspended structures is a natural choice. Use of precast elements will also expedite the construction process. A central precast factory presents itself as an obvious choice over separate units at or near each site for the following reasons:

- reduced requirement of constructional plant and equipment as also working space at various sites

- better use of reusable resources such as shutterings etc.

- better quality control and overall economy

Adoption of a central precast factory for various flyovers, some of them far removed from the factory site, create problems in transporting the precast elements through the congested corridors and these aspects have been given full consideration in evolving the system.

2.2 Geometry and the Structural System

After examining the various flyover locations, an arrangement with central spans to suit each flyover location and viaduct spans of about 18 m is considered to be optimal. The central spans are designed as box girders. These spans could be built in-situ or by using segmental construction using post-tensioned precast box elements. Since the latter method would need elaborate and costly equipments and arrangement at site, it has not been preferred.

For the viaduct portions, the various structural systems that were considered are single cell boxes for each 2 lane carriageway; voided deck system; girder and slab system; and closely spaced beam and slab arrangement. The various alternatives are shown in fig.1. The single cell boxes tend to be uneconomical for short spans and also pose almost insurmountable problems in transporting them using the existing handling infrastructure. The voided deck system negates some of these disadvantages

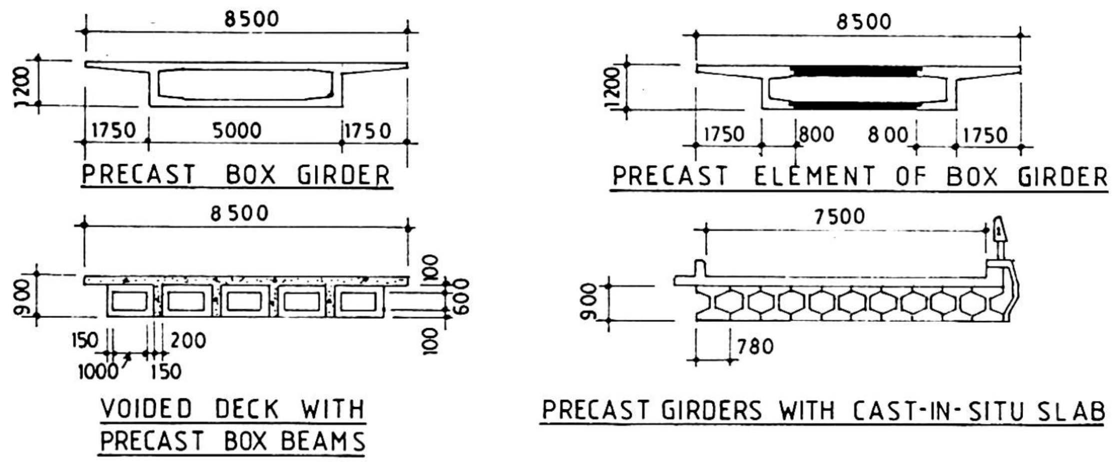


Fig.1 : The various alternatives for the viaduct spans

but needs extended construction site involvement in the form of left-in shutterings. Detailed analysis shows this system to be uneconomical. The girder and slab construction has also negative points within the context of the envisaged construction programme. The girders are too heavy to be transported. The system requires casting of a number of diaphragms and the system does not present an aesthetically pleasing appearance from the under side. These problems can be avoided in closely spaced beams and slab arrangement. The system is aesthetically pleasing, easy for transportation and erection, due to lighter weight of the beams, and is finally adopted for viaduct portions.

While finalising the arrangement the maximum length and weight of the beam which can be handled and transported from the factory to the site were considered. A girder of about 18 m length weighing between 14 to 15 tonnes was considerd optimum. Fig.2 shows the adopted arrangement from the under side.

The proposed arrangement consists of a number of beams which are contigually placed. The actual number of beams across the transverse direction depends on the width of the carriageway. For example, 10 beams are provided for a 7.5 m wide carriageway, 12 for a 9.0 m one and 14 for a 11.0 m one. The deck comprises a 150 mm thick RCC slab laid over the beams and connected by shear connectors embedded in the precast beams.

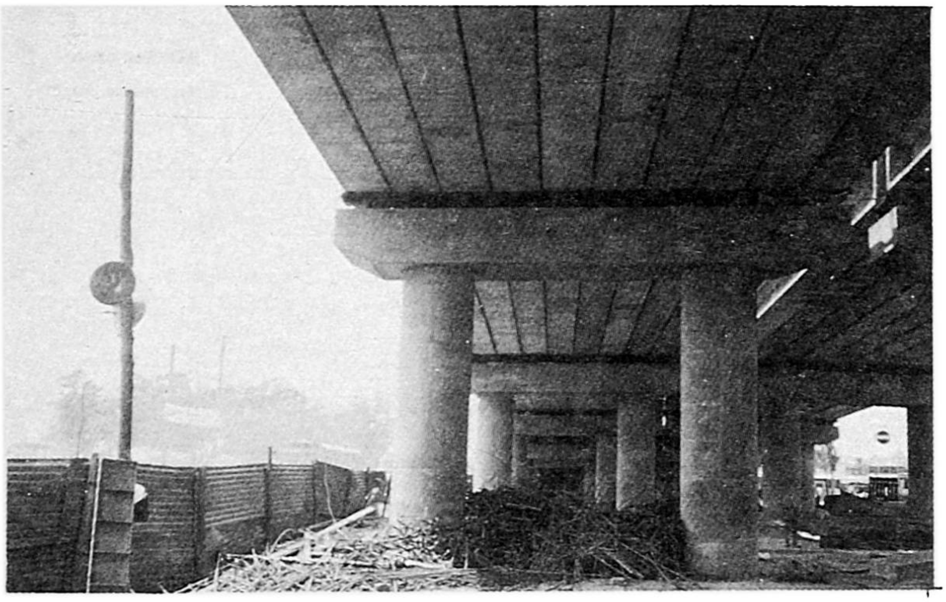
Depending upon the subsoil conditions at the various flyover locations, simply supported or continuous beams were adopted. Fig.3 shows the details over the support of a continuous beam. The beams are 17700 mm long, 780 mm wide, 900 mm deep and weigh 15 t, and were designed using standard procedures.

Specially designed fascia and railing have been used to improve aesthetic appearance, especially at supports.

3. CENTRAL PRECAST FACTORY

3.1 General

A central precast factory was established to carry out the envisioned construction programme. The precast factory comprises the following elements arranged in such a way as to ensure a smooth flow of operaions in a sequential manner:



- automatic concrete batching plant
- wire stacking and reinforcement fabrication yard
- casting, stacking and loading yards
- facilities for steam curing
- testing facilities

3.2 Pretensioned and Precast beams - casting and stacking

The production capacity of the casting yard was 4 girders per day with a provision to augment it to 16 per day. Steam curing and long line method of pretensioning were adopted to increase the turnover of precast elements. Though steam curing entails additional initial outlay for steam production and distribution systems, it was offset by the increased production and the reduced number of bed forms required for the same output.

The reinforcement, assembled in the steel fabrication yard and moved to the casting yard on a trolley, are lifted by two mobile cranes of one tonne capacity and shifted into the moulds. This operation precedes the threading of prestressing strands.

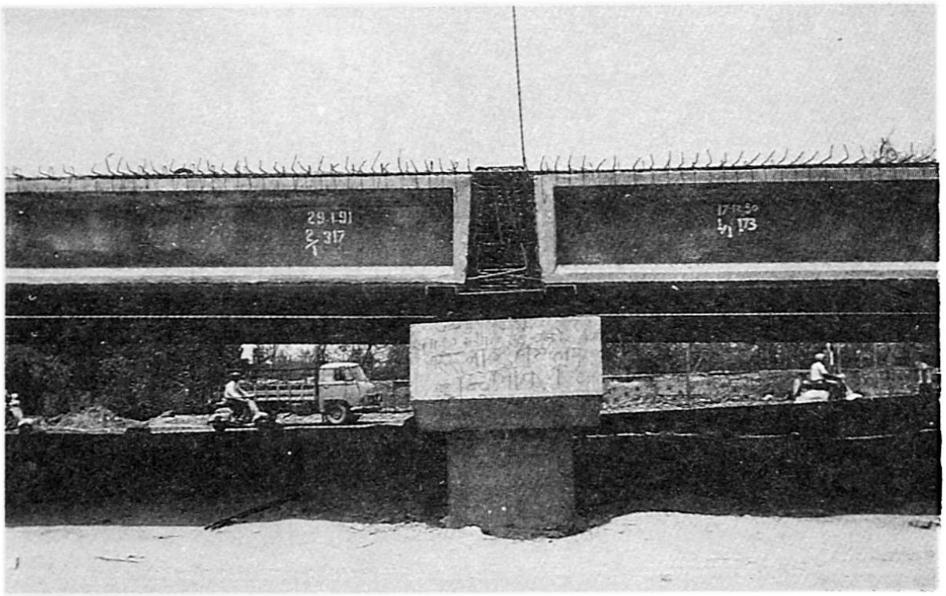
The pretensioned girders, four in number, are cast in one operation in a special mould. All the strands of the girders in the line are stressed simultaneously in one operation. The prestressing force is sustained by steel bulk heads, one of which is movable. Steam curring is adopted and the details of the procedure are presented in section 3.3.

After steam curing the side shuttering is removed and the force in the prestressing jacks is released gradually. The ends of the prestressing strands are cut in accordance with the designed sequence. The girders are moved and and stacked in the stacking yard. Fig.4 shows an overall view of the casting yard.

The stacking and loading yards abutting the casting yard are equipped with a 20 tonne capacity EOT crane for the purpose of moving, hoisting and loading the girders.

3.3 Casting, Curing, Testing and Instrumentation

An automatic concrete batching plant with a production capacity of 30 m^3/hr was proposed adjacent to the casting yard, with separate bins for coarse and fine



aggregates. The batching plant would provide adequately for the daily needs of the casting yard in about 4 hours.

Concreting was proposed to be carried out by using concrete pumps to meet the full production target. However, to start with, concreting was carried out by wing trolley.

Delayed steam curing, with an offset of 3 hours, is adopted to accelerate thermally the hydration of cement, with a view to increasing the turnover of the beams to meet the production target of 100 beams per month. The duration of the curing cycle is about 9 hours - two to three hours to raise the temperture to 70°C and also for cooling down and four hours of incubation at 70°C.

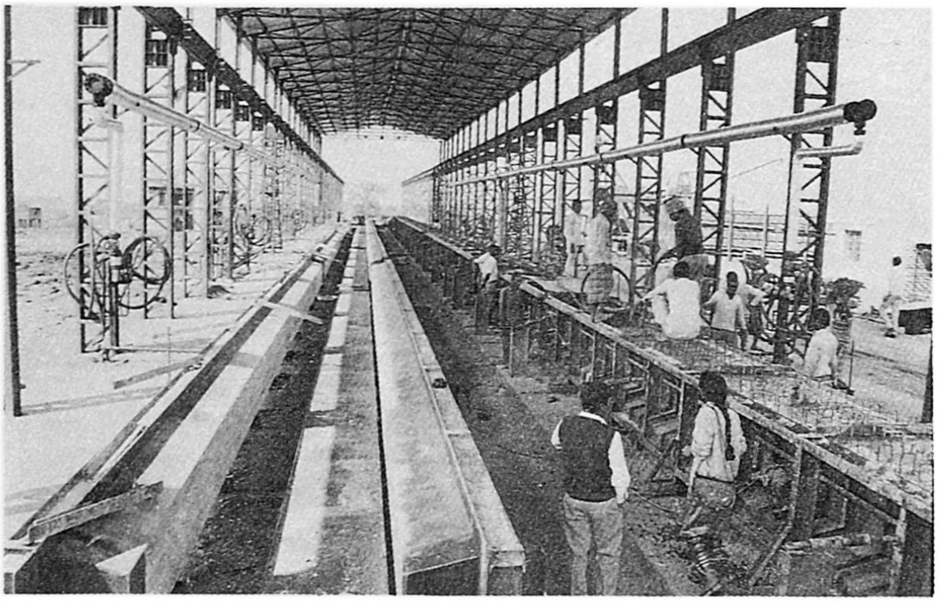
As per initial planning of casting four beams per day, it was sufficient to provide one boiler capable of producing 1500 kg steam per hour and accordingly one boiler was installed. However, two boilers of capacity 1500 kg/hour each, producing steam at a pressure of 10.54 kg/cm^2 are necessary for the peak hour production. Keeping a standby boiler, in case of break down and for maintenance, total number of boilers proposed for the factory was three. More details of steam curing are being included in a separate paper.

A fully equipped field laboratory is proposed to carry out all preliminary tests, works tests and to work out grading and proportioning of aggregates in order to obtain and maintain uniform quality of work as required. Specialised tests, such as for dimensional tolerance, ultimate tensile strength, yield point, 1000 hours relaxation etc. for prestressing strands are proposed to be conducted in an independent laboratory.

More details of precast factory are being included in a separate paper.

3.4 Casting of Fascia

The fascia are proposed to be cast in the precast factory in unit lengths of 2.0 m and transported to the site. The shape and size of fascia are to be decided on considerations of aesthetics and functionality.



4. TRANSPORT OF PRETENSIONED GIRDERS

Before hoisting or transporting the girders, the transfer of prestress force has to be monitored. This is accomplished by fixing strain gauges at the support sections, at quarter points and the mid section. Tests on concrete samples, cured under the same conditions as the girders were, need to be conducted to ascertain the strength of concrete.

From the loading yard, the girders are hoisted on to a 50 t capacity truck trailer. The truck trailer handles three girders at a time.

5. CONCLUSION

The results of an integrated system approach in seeking a standardized design and construction programme for various flyovers in Delhi has been presented with a special emphasis on the precasting the element to an optimal capacity.

It is expected that the results of this exercise could be the forerunner for similar methods to be adopted in other metropolitan cities where rapid construction method without any disruption to the existing traffic flow is the prime consideration.

6. ACKNOWLEDGEMENT

The support of Delhi Tourism and Transportation Development Corporation through the evolution of the schemes and the U.P. State Bridge Corporation though the execution phase are gratefully acknowledged.